Monroe Energy

PHILADELPHIA ENERGY SOLUTIONS

July 27, 2015

The Hon. Gina McCarthy
Administrator
United States Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460
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Dear Ms. McCarthy:

Monroe Energy LLC and Philadelphia Energy Solutions Refining and Marketing LLC (collectively, the "Merchant Refiners Group") respectfully submit these comments on EPA's Notice of Proposed Rulemaking ("NPRM") on the Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017, Docket No. EPA–HQ–OAR–2015–0111, 80 Fed. Reg. 33,100 (June 10, 2015). Among other things, the attached Comments urge EPA to:

- Revise the NPRM's proposal that EPA set the volume requirements for 2016 at the very "boundary between an adequate domestic supply and an inadequate domestic supply." The Merchant Refiners Group strongly supports EPA's decision to use its cellulosic and general waiver authority to reduce the statutory volume requirements. But its proposal to set volume requirements at the boundary of adequate and inadequate domestic supply conflicts with Congressional intent and ignores the reality that any determination of how much renewable fuel can be supplied to consumers in 2016 is inherently uncertain and prone to error. The economic and social costs of erroneous projections are not linear—whereas there is little downside risk in under-projecting domestic supply, projections that prove too high will dramatically increase RIN prices and price volatility, and will deplete carry-over RIN stocks, which EPA has recognized should be maintained.

- Accept what all the empirical evidence shows—that the current RFS program is a particularly poor mechanism to incent the consumption of higher ethanol blends. EPA offers a theory that higher RIN prices will lower E85 prices, making that fuel more competitive with E10, thereby incenting greater E85 use. But, as a recent study by Christopher Knittel, Ben Meiselman, and James Stock demonstrated, the pass-through of RIN prices to the E85-E10 spread nationwide "is precisely estimated to be zero if one adjusts for seasonality." Evidence of no or only modest growth in E85 stations since 2012 further confirms the fallacy of EPA's theory. And the evidence also demonstrates that the parties whom EPA has burdened with RFS obligations are not well situated to eliminate the bottleneck that prevents the value of RINs from being passed through to consumers.

- Correct the NPRM's significant underestimate of the demand for E0. EPA's failure to account for what its own data sources reveal about E0 consumption caused it to significantly understate the gap between the amount of renewable fuel that EPA proposed to mandate in transportation fuels and the amount it assumed the economy was actually on pace to supply in transportation fuels. EPA must revise its mandates for 2015 and 2016 to appropriately account for E0 demand.

- Correct the NPRM's failure to recognize legal and structural limitations on the effective biomass-based diesel mandates in 2015 and 2016, and reduce all three mandates to account for the limits. EPA likewise must adjust its over-aggressive expectations with respect to the supply of other advanced renewable biofuels, including supply of cellulosic-based biofuels.

Most importantly, the Merchant Refiners Group urges EPA to shift the RFS compliance obligation to blenders. As noted above, the key mechanism on which EPA relies to induce increased consumption of high-ethanol blends—a subsidy to renewable fuels provided by RINs—is not functioning properly. The value of RINs is not being passed through to consumers. It would be irrational for EPA to continue imposing larger mandates without diagnosing the problem and addressing the mechanism through which it expects the economy to meet those mandates. If EPA is serious about using the RFS to subsidize high renewable-content fuels, it must shift obligations closer to the cause of the bottleneck that prevents RIN values from being passed through to retail consumers.

Attached as Exhibit A to these Comments is a recent empirical study, by Christopher R. Knittel, et al., entitled "The Pass-Through of RIN Prices to Wholesale and Retail Fuels under the Renewable Fuel Standard." Attached as Exhibit B is recent paper by James H. Stock, "The Renewable Fuel Standard: A Path Forward," Columbia/SIPA Center on Global Energy Policy.

Sincerely,

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RE: Comments on Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017
Docket No. EPA–HQ–OAR–2015–0111, 80 Fed. Reg. 33,100 (June 10, 2015)

Monroe Energy LLC and Philadelphia Energy Solutions Refining and Marketing LLC (collectively, the "Merchant Refiners Group") respectfully submit these comments on EPA's Notice of Proposed Rulemaking ("NPRM") with respect to the Renewable Fuel Standard Program for 2014-16.[1] In its NPRM, EPA correctly recognized that the E10 blendwall prevents the use of renewable fuel at the volume levels specified in the Clean Air Act. In imposing these statutory volumes, Congress expected that the cellulosic biofuels industry would experience robust growth and that transportation fuel use would continue to rise.[2] Neither expectation has come to pass. Instead, the cellulosic biofuel industry remains in its infancy, and gasoline usage has significantly declined. As a result, the statutory volume levels are now grossly in excess of the amount of renewable fuel that the economy can supply in transportation fuel to consumers. Accordingly, EPA appropriately has proposed to exercise both its cellulosic waiver authority and

[1] Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017, 80 Fed. Reg. 33,100 (June 10, 2015) ("NPRM").

[2] *Id.* at 33,101.

its general waiver authority to reduce the volume requirements to a level that was actually achieved in 2014[3]—as the year is already complete—and that it suggests can actually be achieved in the few months that remain in 2015.[4]

For 2016, EPA also correctly invoked its waiver authorities to reduce the statutory volume requirements. However, EPA erred in proposing to set the volume requirements at the very "boundary between an adequate domestic supply and an inadequate domestic supply."[5] As EPA elsewhere acknowledged in the NPRM, any determination of how much renewable fuel can be supplied to consumers in 2016 is inherently uncertain and prone to error. The consequences of aiming too high are severe: obligated parties could be left unable to comply. And Congress did not intend to put obligated parties "in an impossible position, or at least a highly punitive one" in which they face penalties due to structural conditions beyond their control.[6] Moreover,

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[3] Because no additional 2014 RINs can be made available for compliance in 2014, the Merchant Refiners Group agrees in principle with EPA's decision to set 2014 mandates no higher than the number of RINs that were actually made available for compliance in 2014. However, EPA continues to struggle with limitations on its ability to determine the number of D6 RINs that will be available for compliance in 2014. *See* Korotney, "Memo to docket on correction to the determination of 2014 RIN supply to account for ethanol exports" (Jul. 24, 2015). For that reason, EPA should either leave 2014 volumes as proposed or—instead of relying on RIN generation figures that risk overstating actual *supply* in transportation fuel in 2014—EPA should use other available data, such as EIA's May STEO 2015 figures on ethanol consumed in 2014. Whatever approach it chooses, for the reasons set forth below, it is of paramount importance that EPA not intentionally set standards that will draw down stocks of carryover RINs.

[4] While these Comments focus on EPA's proposed mandates for 2016, the Merchant Refiners Group observes that EPA's proposed mandates for 2015 are infected with many of the same errors highlighted below. For example, in setting 2015 mandates, EPA: (i) disregards significant E0 usage; (ii) adopts the fallacy that the current RFS program can incent meaningful growth in E85; (iii) ignores structural constraints that prevent ramping up biomass-based diesel production, as well as limitations on meaningfully increasing sugarcane ethanol imports; and (iv) adopts unrealistic projections for cellulosic biofuel production. As a consequence, for the same reasons discussed below regarding 2016, the Merchant Refiners Group urge EPA to revise the 2015 proposed mandates.

[5] NPRM, 80 Fed. Reg. at 33,104.

[6] *See Am. Petroleum Inst. v. EPA*, 706 F.3d 474, 479 (D.C. Cir. 2013).

the cost of error is decidedly not linear—projections that prove too low will have only a small impact on RIN prices, whereas projections that prove too high will dramatically increase RIN prices and price volatility, and may make compliance impossible. Thus, in setting volume requirements pursuant to the general waiver authority, it is critical that EPA leave a certain degree of breathing room to account for the possibility of error.

Making matters still worse, for 2016 EPA has presented overly optimistic projections of renewable fuel production and usage—projections that leave no breathing room and cannot be squared with the sources of data EPA has relied upon or with production and usage levels so far in 2015. First, the NPRM underestimated the size of the gap between the amount of renewable fuel that EPA proposed to mandate in transportation fuels in 2016 and the amount it assumed the economy was actually on pace to supply in transportation fuels in 2016. Second, EPA's scenarios for closing that gap ignore empirical realities. EPA primarily relies on RIN prices as a mechanism to subsidize high-ethanol blends, thereby creating incentives for blenders and retailers to provide, and consumers to use, such blends. However, the data show that the value of RINs are not passed through to consumers in the form of a larger spread between E10 and E85 prices. As a recent study by Christopher Knittel, Ben Meiselman, and James Stock demonstrated, the pass-through of RIN prices to the E85-E10 spread "is precisely estimated to be zero if one adjusts for seasonality."[7] They conclude that "[i]f the RIN price savings inherent in blends with high biofuels content are not passed on to the consumer, then this key mechanism of

[7] Christopher R. Knittel et al., *The Pass-Through of RIN Prices to Wholesale and Retail Fuels under the Renewable Fuel Standard*, 2 (June 2015), *available at* http://scholar.harvard.edu /files/stock/files/pass-through_of_rin_prices_1.pdf (attached as Exhibit A).

the RFS is not functioning properly."[8] EPA has offered no reason to expect that to change in the next six to eighteen months.

Accordingly, at least half of EPA's scenarios to fill the "gap" resulting from its proposed mandates significantly overestimate the amount of E85 that the economy is likely to supply in 2016. In order to satisfy the mandates, the economy instead will need to produce biomass-based diesel at or near levels that EPA has described as merely "theoretical[],"[9] and a variety of other renewable fuels the availability of which has varied widely in recent years.

Finally, EPA must consider shifting the compliance obligation to blenders and away from refiners and importers. As noted above, the key mechanism on which EPA relies to induce increased consumption of high-ethanol blends—a subsidy to renewable fuels provided by RINs—is not functioning properly. The value of RINs is not being passed on to consumers in the form of relatively lower E85 prices. It would be irrational for EPA to continue to impose increasing mandates without addressing the failure of the mechanism on which it expects the economy to rely in meeting those mandates. The current obligated parties—refiners and importers—are poorly situated to address the problem. Complex structural constraints on the retail E85 market prevent the value of RINs from being passed through to retail E85 prices, and refiners—especially merchant refiners—are in no position to remove those constraints or otherwise change the behavior of blenders or retailers. But placing the obligation on blenders would help. As obligated parties, blenders would have a stronger, more direct incentive to blend and sell as much E85 as possible, and, because they are closer in the supply chain to retailers, they could exert pressure over retailers to ensure that the RIN subsidies needed to promote the use of higher-ethanol blends are passed on to the ultimate consumer. Because of their closer

[8] *Id.* at 20.

[9] NPRM, 80 Fed. Reg. at 33,129.

relationships with retailers, blenders are also better situated than refiners or importers to assist in overcoming the infrastructure constraints that have inhibited growth in E85 usage and the pass-through of RIN value to consumers.

Accordingly, EPA should shift the compliance obligation to blenders.

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I. THE NPRM CORRECTLY CONCLUDES THAT EPA HAS AUTHORITY TO REDUCE THE STATUTORY VOLUME REQUIREMENTS.

EPA has the authority to reduce the statutory volume requirements by waiving them. As EPA stated in the NPRM, the agency may exercise its waiver authority under both Section 211(o)(7)(A)(ii) and Section 211(o)(7)(D)(i) of the Clean Air Act. Here, the Merchant Refiners Group focuses on the general waiver authority set forth in Section 211(o)(7)(A)(ii), which allows EPA to waive the volume requirements in the event of "inadequate domestic supply."

Under that Section, EPA can and should waive the statutory volume requirement for total renewable fuels. And in setting a new volume requirement, EPA should ensure that "domestic supply" will be adequate by leaving sufficient breathing room to account for the significant uncertainty surrounding projected volumes.

A. There Is An "Inadequate Domestic Supply" of Renewable Fuel That Can Be Consumed as Transportation Fuel.

The general waiver authority, Section 211(o)(7)(A), states in relevant part:

> The Administrator, in consultation with the Secretary of Agriculture and the Secretary of Energy, may waive the [statutory volume] requirements . . . in whole or in part . . . by the Administrator on his own motion by reducing the national quantity of renewable fuel . . . —
> . . . (ii) based on a determination by the Administrator, after public notice and opportunity for comment, that there is an inadequate domestic supply.[10]

The key statutory phrase is "inadequate domestic supply." The statutory language does not specify *what* supply must be inadequate nor the *purpose* against which adequacy is to be

[10] 42 U.S.C. § 7545(o)(7)(A).

assessed. This leaves EPA with considerable discretion to decide how to apply the waiver authority in a manner consistent with the statutory purpose.[11]

EPA's interpretation of the phrase "inadequate domestic supply," as authorizing it "to consider the full range of constraints, including legal, fuel infrastructure, and other constraints, that could result in an inadequate supply of renewable fuels to consumers,"[12] is clearly permissible. Indeed, that is the most logical interpretation of the statute. The benefits that Congress sought to bring about through the statute—energy independence and a reduction in greenhouse gas emissions—can only be achieved if renewable fuels are ultimately supplied to consumers in place of the fossil fuels they would otherwise consume.[13]

Congress understood this. The statute charges EPA with ensuring that "transportation fuel sold or introduced into commerce in the United States" contains particular volumes of renewable fuel.[14] And the term "renewable fuel" is defined to mean "fuel that is produced from renewable biomass and that is *used to replace or reduce* the quantity of fossil fuel present *in a transportation fuel*."[15] For that reason, as EPA explained, the adequacy of supply *must* account for the various factors that constrain the market's ability to supply renewable fuels to the vehicles that can consume them as transportation fuel.[16] After all, it would not advance statutory objectives to mandate the production of renewable fuel that cannot feasibly be blended into the transportation fuel supplied to consumers.

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[11] *See EPA v. EME Homer City Generation, L.P.*, 134 S. Ct. 1584, 1603 (2014) (citing *Chevron U.S.A., Inc. v. Natural Resources Defense Council, Inc.*, 467 U.S. 837, 843, 866 (1984)).

[12] NPRM, 80 Fed. Reg. at 33,113.

[13] *See id.*

[14] 42 U.S.C. § 7545(o)(2)(A)(i).

[15] 42 U.S.C. § 7545(o)(1)(J) (emphasis added).

[16] 80 Fed. Reg. at 33,113.

B. EPA Correctly Refused to Consider Banked RINs In Its Determination of Whether There Was "Inadequate Supply" of Renewable Fuel That Can Be Consumed.

In determining the degree to which supply was "inadequate" in 2014, 2015, and 2016, EPA correctly refused to consider RINs that had been or will be carried over from prior compliance periods. As EPA explained, "carryover RINs are intended to provide flexibility in the face of a variety of circumstances that could limit the availability of RINs, including weather-related damage to renewable fuel feedstocks and other circumstances affecting the supply of renewable fuel that is needed to meet the standards."[17] Parties may carry forward an unlimited number of credits, use those credits to satisfy up to 20 percent of their present year's volume requirement, and sell the remainder.[18] Thus, obligated parties who accumulated excess credits in 2014 (for example, integrated blender-refiners who blended more than they refined) will likely seek to carry forward some number of those 2014 credits for use and/or sale in 2015. The same is true for 2015 and each subsequent year.

While some stakeholders have argued that EPA should set volume requirements based upon supply projections *and* all "banked" RINs, EPA correctly refused to do so. That is so for several reasons. First, carryover RINs act as a buffer that facilitates compliance even in unforeseen circumstances—for example, a drought that increases corn prices and significantly changes the economics of blending ethanol into E10. As EPA has explained, "we believe that carryover RINs serve an important function under the program, including providing a means of compliance when natural disasters cause unexpected supply limitations."[19] Intentionally depleting the bank of carryover RINs by setting volume requirements too high would mean that

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[17] *Id.* at 33,129.

[18] 40 C.F.R. § 80.1427(a)(3), (5).

[19] NPRM, 80 Fed. Reg. at 33,114.

parties would have diminished compliance flexibility in the future in the event of unforeseen circumstances, such as a drought.

Second, because of the E10 blendwall, blenders will no longer be able to produce excess RINs simply by blending ethanol in excess of EPA's volume percentage requirement, as they were able to do during the 2010-12 time period.[20] Thus, if obligated parties are forced to retire carryover RINs, they are unlikely to be able to replenish the RIN bank in future periods. Any depletion in carry-over RINs is likely to be permanent. As EPA explained, "any draw-down in the bank of carryover RINs required through setting volume requirements at levels higher than can be achieved through actual renewable fuel use could not likely be reversed in the future."[21]

Third, the current RIN bank is not particularly large. EPA estimated in the NPRM that approximately 1.8 billion RINs will remain banked after parties have demonstrated compliance with the 2013 standards.[22] Roughly speaking, that is only 11 percent of the total number of RINs that parties will be expected to retire in order to satisfy the proposed 2015 standards, and merely 10 percent of the proposed 2016 standards (assuming no draw down), based on EIA projections that EPA used for total gasoline consumption.

That is significantly smaller than the 20 percent of volume requirements that EPA deemed appropriate in its rulemakings establishing the RIN system. In the 2007 rulemaking establishing the RFS program, EPA found that supply problems of 20 percent could exist in a single year and adopted the rule that permits obligated parties to meet up to 20 percent of their obligations in a particular year using RINs carried over from the prior year.[23] In adopting the 20

[20] *Id.* at 33,129-30.

[21] *Id.* at 33,130.

[22] *Id.*

[23] *See* 40 C.F.R. § 80.1427(a)(1), (5).

percent rule, EPA explained that with respect to supply and demand for RINs, the 20 percent allowance provides "the appropriate balance between . . . protecting against potential supply shortfalls that could limit the availability of RINs, and . . . ensuring an annual demand for renewable fuels as envisioned by the Act."[24] EPA rejected arguments from renewable fuel producers that a carryover RIN cap closer to 10 percent would provide sufficient cushion for supply shortages.[25] EPA's principal concern was that 10 percent carryover would be insufficient to account for potential shortages in ethanol supply. EPA explained that "[t]he level of 20 percent is consistent with past ethanol market fluctuations."[26] EPA gave the example of 1996, a year in which, as a result of a drought, ethanol supply had diminished by 21% as compared with the prior year.[27] In the 2010 rulemaking adopting amendments to the RFS program, EPA again affirmed the appropriateness of the 20 percent number.[28]

Thus, if anything, current carryover RIN stocks are already too *low* to fully serve as a buffer against unforeseen problems with supply. Certainly, EPA should not set standards so as to intentionally reduce those stocks further. And EPA has acknowledged that its standard-setting is a "very challenging task not only in light of the myriad complexities of the fuels market and how individual aspects of the industry might change in the future, but also because we cannot precisely predict how the market will respond to the volume-driving provisions of the RFS

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[24] Regulation of Fuels and Fuel Additives: Renewable Fuel Standard Program, 72 Fed. Reg. 23,900, 23,934-35 (May 1, 2007).

[25] *Id.* at 23,935.

[26] *Id.*

[27] *Id.*

[28] Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program, 75 Fed. Reg. 14,670, 14,735 (Mar. 26, 2010) ("2010 Rule").

program."[29] Given the significant possibility that EPA has overestimated the amount of renewable fuel that will be consumed in 2016—which we discuss further below—it would be particularly imprudent for EPA to intentionally deplete existing stocks of carryover RINs in setting standards for 2014 and 2015.

Finally, carryover RINs are not themselves a "supply" of renewable fuel that EPA must consider in exercising its general waiver authority. Carryover RINs represent renewable fuel that was blended and consumed in the past. Setting standards so high as to require parties to surrender carryover RINs to demonstrate compliance would not actually increase the quantity of renewable fuel in transportation fuel, and thus would not advance the purposes of the statute.

For all these reasons, EPA correctly determined that setting standards so as to effectively require the depletion of carryover RINs would not be consistent with the "the critical compliance flexibility, market liquidity, and program buffer functions served by carryover RINs."[30]

C. In Exercising Its General Waiver Authority, EPA Should Reduce the Statutory Volume Requirement to a Level That Will Ensure an Adequate Domestic Supply.

1. Because EPA's projections are inherently uncertain, and the RIN market does not behave like an ordinary competitive market, EPA must consider the consequences of setting a volume requirement that is too high and must leave sufficient breathing room to account for the likelihood of error.

In exercising its general waiver authority to address "inadequate domestic supply," EPA obviously must reduce volume requirements to the level where supply is "adequate." It has interpreted that to mean it should set the volume requirements at the very "boundary between an adequate domestic supply and an inadequate domestic supply."[31] In other words, EPA is

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[29] NPRM, 80 Fed. Reg. at 33,105.

[30] *Id.* at 33,130.

[31] *Id.* at 33,104.

"seeking to determine the maximum volumes of renewable fuel that can be expected to be achieved in light of supply constraints."[32] As EPA has put it, the proposed requirements are "forward-leaning."[33]

The difficulty is that the maximum volumes of renewable fuel that can be expected to be introduced into transportation fuel cannot be determined with pinpoint accuracy. Instead, as EPA's withdrawn 2014 Notice of Proposed Rulemaking openly acknowledged, there are a range of potential scenarios that could occur with different probabilities.[34] While that probabilistic distribution may produce an expected value, the variation around that expected value could be significant. And it is difficult even to identify the probabilistic distribution with any accuracy. Thus, as EPA recognized in the NPRM, determining the amount of renewable fuel that can be expected to be introduced into transportation fuel in the future is "a very challenging task not only in light of the myriad complexities of the fuels market and how individual aspects of the industry might change in the future, but also because we cannot precisely predict how the market will respond to the volume-driving provisions of the RFS program."[35] The most EPA can offer is its guess as to "where the intersection between adequate domestic supply and inadequate domestic supply *might* fall."[36]

Because EPA's projections are inherently uncertain, EPA must consider the adverse consequences of setting a volume requirement that is too high, and it must leave sufficient breathing room to account for the possibility (indeed, likelihood) of error in its projections. This

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[32] *Id.* at 33,105.

[33] *Id.* at 33,102.

[34] 2014 Standards for the Renewable Fuel Standard Program, 78 Fed. Reg. 71,732 (Nov. 29, 2013).

[35] NPRM, 80 Fed. Reg. at 33,105.

[36] *Id.* at 33,117 (emphasis added).

is critical given the dynamics of the RIN market, where the cost of EPA erring is decidedly not linear—projections that prove too low will have only a small impact on RIN prices, whereas projections that prove too high will dramatically increase RIN prices and price volatility. And a waiver that is too small to remedy the problem of "inadequate domestic supply" would fall outside the waiver that Congress authorized. The NPRM nowhere considers this important aspect of the problem.

Accordingly, EPA should be conservative in setting volume requirements, to ensure domestic supply is *in fact* adequate to meet those requirements—not just that it "*might*" be adequate.[37] As EPA stated in the NPRM, "[t]he RFS standards are a mandate with serious ramifications to obligated parties that fail to comply."[38] At minimum, a compliance requirement set too high would result in "greater volatility in RIN prices and greater difficulty for obligated parties in obtaining RINs and in planning and implementing an orderly compliance strategy."[39] Setting requirements at the very "boundary between an adequate domestic supply and an inadequate domestic supply"[40] also threatens to negate the wisdom of EPA's decision to maintain carry-over RIN stocks. Every time EPA even slightly crosses the boundary into inadequate supply, obligated parties must chip away at finite RIN stocks, leaving them dangerously exposed in the event of a not-uncommon future drought or other occurrences that can sharply effect domestic supply. EPA has already recognized the danger of such circumstances, remarking that it "would be disruptive to businesses and therefore to the long-term objectives of the RFS program" to have to change its mandates during the compliance year

[37] *Id.* (emphasis added).

[38] *Id.* at 33,130.

[39] Interagency Comments Part 9a: Email from Jim Laity, OMB, to Karl Simon, EPA Office of Transportation and Air Quality (Oct. 24, 2013 7:25 PM), EPA-HQ-OAR-2013-0479-0003.

[40] NPRM, 80 Fed. Reg. at 33,104.

"to address unforeseen supply disruptions or for other reasons…."[41] (Conversely, if EPA sets the volume requirement somewhat lower than the economy ends up using, parties could generate excess RINs, helping to rebuild RIN stocks closer to the 20 percent level that EPA has previously found to be prudent.)

Even worse, if EPA sets unachievable volume requirements, some obligated parties—in particular, merchant refiners who must purchase most if not all of their RINs on the secondary market—could be left altogether unable to comply if parties with access to excess RINs choose to hoard them rather than make them available on the secondary market. EPA recognized this possibility, stating that "parties that accumulate RINs through their own blending activities could decide to bank the maximum quantity of RINs for their own future use or for future sale, and that if this practice were widespread that there could be a shortfall in available RINs for parties who do not engage in renewable fuel blending activities themselves…." [42]

EPA nevertheless dismissed the significance of this possibility, asserting that it exists "in any competitive marketplace."[43] The Merchant Refiners Group's experience purchasing in the secondary RIN market, however, is that this market does not behave like an ordinary competitive market. In an ordinary market, increasing demand for RINs would induce additional supply, thereby allowing supply and demand to reach equilibrium. That is not so in the RIN market. Demand is inelastic—obligated parties *must* submit the necessary quantity of RINs—and, as EPA recognized elsewhere in the NPRM, now that the economy has hit the E10 blendwall, supply is also largely inelastic. Blenders no longer can create additional RINs through over-blending. When inelastic supply is combined with anticipated increases in volume requirements

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[41] *Id.* at 33,130.

[42] *Id.* at 33,108.

[43] *Id.*

in future years—thereby increasing the risk EPA will set volume requirements beyond the economy's ability to supply renewable fuel to consumers—the result will be to significantly increase the option value of banked RINs, raising their price and making their holders less willing to part with them. An ordinary competitive market would not exhibit such behavior. Moreover, in the Merchant Refiners Group's experience, the RIN market is often very thin and pricing is opaque. In a truly competitive market, by contrast, pricing would be transparent and significant volumes would be traded.

The fact that EPA believes that the RIN marketplace is a functioning competitive marketplace—even though it was wholly created by government regulation and its pricing depends upon predictions about how the renewable fuels industry might respond to future command-and-control decisions by EPA—demonstrates the error in EPA's entire approach.

2. EPA's assumption that it has a responsibility to move the E10 blendwall by pushing increased use of E85 is incorrect and misreads Congressional intent.

As described below, EPA further erred by setting volume requirements intended to "drive growth" of conventional ethanol, which, according to the NPRM, "Congress intended."[44] Given the context in which Congress passed the Renewable Fuel Standard, that is decidedly incorrect. The statutory volumes set for 2016 imply a conventional ethanol mandate of only 67 percent of the total renewable fuel volume target—in contrast to the NPRM's implied ethanol mandate of about 80 percent of the total renewable mandate.[45] Moreover, Congress never contemplated that its volume mandates would require the economy to breach the E10 blendwall through the use of conventional ethanol. By comparing the statutory mandates to the 2007 EIA projections of gasoline consumption that Congress used to set them, one sees that Congress' goals for

[44] *Id.* at 33,128.

[45] *Id.* at 33,126.

conventional ethanol relative to gasoline use were about 9.4 percent in 2014, 9.6 percent in 2015; and 9.5 percent in 2016. These percentages provide an important historical counter-weight to EPA's suggestion that Congress expressly intended EPA to drive the use of conventional ethanol past the E10 blendwall with high-ethanol blends, such as E85. Congress instead envisioned a cellulosic fuels revolution that never materialized, along with steadily increasing gasoline consumption that has since retreated.

In sum, EPA must, when exercising its general waiver authority, leave sufficient breathing room to ensure that the purpose of the waiver is achieved—that a situation of "inadequate domestic supply" will not occur. By pushing the volume requirements right to the boundary of adequate and inadequate supply, based on "forward-leaning" estimates of what EPA believes "might" occur in response to the standards it promulgates, EPA has failed to leave a sufficient margin for error. Congress did not intend to place obligated parties in "an impossible position, or at least a highly punitive one."[46] Yet that is exactly what will result if EPA's projections are unrealized in practice.[47]

II. EPA HAS OVER-ESTIMATED THE ECONOMY'S ABILITY TO CONSUME RENEWABLE FUEL AND THE RFS PROGRAM'S ABILITY TO INCENT IT.

As discussed above, EPA's decision to set volume requirements right at the boundary of adequate and inadequate supply, and to estimate adequate supply without accounting for the uncertainty inherent in its projections, create a significant risk that its waiver will be insufficient to ensure "adequate domestic supply." That risk is magnified in 2016 because EPA has proposed

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[46] *Am. Petroleum Inst.*, 706 F.3d at 479.

[47] The Merchant Refiners Group also adopts the argument by the American Petroleum Institute and the American Fuel and Petrochemical Manufacturers that a waiver is justified because imposing the full statutory volume requirements would cause severe economic harm. *See* 42 U.S.C. § 7545(o)(7)(A)(i).

to mandate the usage of 840 million gallons of renewable fuel in excess of the amount that the economy was on pace to use when the NPRM issued.

EPA's projections are flawed in two key respects. First, EPA significantly overestimated the amount of ethanol the economy was on pace to blend with gasoline.[48] Once that error is rectified, it is clear EPA created nearly a 1.1 billion gallon gap between its mandate and the amount of renewable fuel that the economy was on pace to use when the NPRM issued.[49] Second, at least half of the compliance scenarios set forth by EPA involve a massive increase in the volume of high-ethanol blends used in 2016. EPA reasons that the economy will be capable of significantly increasing usage of high-ethanol blends based on the theory that revenue from high RIN prices will trickle down to consumers in the form of competitively-priced E85, which consumers will then have reason to purchase.[50] The latest empirical data, however, indicate that this theory is not borne out in reality. The value of RINs has not been passed through to consumers nationwide in the form of competitively-priced E85, and the market has not significantly expanded E85 infrastructure in response to more than two and a half years of high RIN prices. EPA has no basis for expecting any material change to occur in these respects within the next six to eighteen months.

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[48] *See, e.g.*, Scott Irwin & Darrel Good, Dep't of Agric. & Consumer Econ., University of Illinois at Urbana-Champaign, *Implementing the RFS with a 'Push' Strategy: What Happens after 2016?*, *farmdoc daily* (5):112, June 17, 2015, *available at* http://farmdocdaily.illinois.edu/pdf/fdd170615.pdf.

[49] *Id.*

[50] *See* NPRM, 80 Fed. Reg. at 33,128 ("We recognize that the market would need to compel E85 prices to be increasingly favorable relative to E10 in order to provide the incentive for FFV owners to purchase E85, but this is exactly how a fully functional market will react to standards designed to drive growth in renewable fuel as Congress intended. Thus we believe it is possible for the market to reach volumes perhaps as high as 600 million gallons under favorable pricing Conditions.").

As a result, in order to satisfy EPA's proposed mandates, the economy will need to produce biomass-based diesel at or near levels that EPA has described as merely "theoretical[]."[51] EPA must adjust its volume requirements for 2016 in light of this empirical evidence and real-world constraints.

A. EPA Has Understated the 2016 Renewable Gap By Several Hundred Millions of Gallons of Biofuels.

According to the NPRM, there is an 840-million-gallon gap between the amount of renewable fuel that EPA assumed the market was on pace to use and the amount mandated by the 2016 advanced and total renewable requirements that EPA has proposed. The methodology EPA used to calculate this gap is simple. EPA began with the proposed total renewable mandate for 2016 of 17.40 billion gallons, and then subtracted (i) the amount of ethanol it assumed would be consumed as E10, based on then-current gasoline projections; (ii) the non-ethanol portion of the cellulosic mandate, which EPA assumed is 170 million gallons; and (iii) the biomass-based diesel mandate. EPA's table showing this methodology is reproduced below:

TABLE II.D.2–1—BREAKDOWN OF RENEWABLE FUEL USE IN 2016 BASED ON PROPOSED VOLUMES

[Billion ethanol-equivalent gallons]

Total renewable fuel	17.40
Ethanol consumed as E10[a]	−13.69
Non-ethanol cellulosic biofuel	−0.17
Biomass-based diesel[b]	−2.70
Additional renewable fuel that must be used	0.84

[a] Includes all sources of ethanol (cellulosic, advanced, and conventional)

[b] Represents 1.80 billion physical gallons.

[51] *Id.* at 33,129.

According to EPA, that leaves a gap of 840 million gallons of renewable fuel that must be used in order to meet the proposed mandates, but which the economy was not on pace to use. In order for the proposed volume requirements to be achievable, that gap must be closed.

However, the NPRM significantly understated the gap. Estimates using the same data sources used by EPA indicate that, in fact, the gap is likely closer to 1.1 billion gallons. EPA's understatement is due to it significantly overestimating the amount of ethanol the economy was on pace to consume as E10.

In projecting that the economy will consume 13.69 billion gallons of ethanol as E10 in 2016, EPA appears to have used EIA's May 2015 Short-Term Energy Outlook ("STEO") data for total gasoline consumption and multiplied that figure by about 9.96 percent, presumably to account for the E10 blendwall.[52] Yet, as economists Scott Irwin and Darrel Good have observed, that very same EIA data projected the economy was then on pace to consume only *13.46* billion gallons of ethanol *in total* (*i.e.*, including E15 and E85) in 2016—about 230 million gallons fewer than EPA projections of ethanol in E10 alone.[53] That is because EIA expected ethanol to represent only 9.78 percent (not 9.96 percent) of gasoline consumption in 2016.[54]

[52] Specifically, EPA stated that its figure represents the "maximum ethanol consumption as E10" and is "[d]erived from projected gasoline energy demand from EIA's Short-Term Energy Outline (STEO) from May 2015." NPRM, 80 Fed. Reg. at 33,115.

[53] Elsewhere in the NPRM, EPA acknowledged EIA's projections that the economy is on pace to consume only 13.46 billion gallons of ethanol in 2016—and not EPA's estimated 13.69 billion gallons. Specifically, in converting EPA's volumetric requirements into fractional requirements based on EIA total gasoline consumption figures, EPA recognized that it must reduce EIA total gasoline figures by the 13.46 billion gallons of ethanol EPA projects the economy will consume. *See id.* at 33,147 ("Note that because the gasoline and diesel volumes estimated by EIA include renewable fuel use, we must subtract the total renewable fuel volumes from the total gasoline and diesel volumes to get total nonrenewable gasoline and diesel volumes.").

[54] EPA, Calculation of Percentage Standards for 2014, 2015, and 2016, EPA-HQ-OAR-2015-0111-0005 (June 10, 2015); *see also* U.S. Energy Info. Admin., *Short-Term Energy Outlook*, Table 4A, May 2015, *available at* http://www.eia.gov/forecasts/steo/archives/May15.pdf.

According to Irwin and Good, the 9.78 percent ethanol inclusion rate in EIA's May 2015 STEO reflected continued use of E0 gasoline.[55] In the NPRM, EPA projected that "the use of E0 . . . would only reduce the total volume of ethanol that can be consumed by about 13 million gallons out of the 13.69 billion gallons we estimated above."[56] But the data then available to EPA showed that E0 use is much greater. And the data are consistent with historical trends. In their comments to the current NPRM, the American Petroleum Institute ("API") and the American Fuel & Petrochemical Manufacturers ("AFPM") review EIA historical data on E0 demand, and discover that demand averaged 6.5 billion gallons per year—or 5 percent of annual gasoline demand—between 2012 and 2014. Demand for E0 hit its lowest in 2012, at only 3 percent of gasoline demand. Taking that level as a conservative reference point, they argue that the 2016 mandate should reflect total ethanol consumption equal to 9.7 percent of gasoline consumption, plus an additional 100 million gallons of E85. This conservative recommendation reflecting the impact of E0 on ethanol consumption is roughly in line with EIA's May 2015 STEO projection of a 9.78 percent ethanol inclusion rate for 2016.

[55] *See* Scott Irwin & Darrel Good, Dep't of Agric. & Consumer Econ., University of Illinois at Urbana-Champaign, *The EPA's Proposed Ethanol Mandates for 2014, 2015, and 2016: Is There a 'Push' or Not?*, *farmdoc daily* (5):102, at 3, June 3, 2015 ("It is not surprising that the ethanol inclusion rate does not reach 10 percent due to small amounts of E0 still in use in some areas of the U.S."), *available at* http://farmdocdaily.illinois.edu/pdf/fdd030615.pdf. Good and Irwin observe there are actually two gaps—one for advanced biofuels and one for conventional biofuels. This results because, although advanced biofuels can be used to meet the total renewable mandate, conventional biofuels cannot be used to meet the advanced mandate. After concluding that the NPRM creates a 222 million gallon advanced biofuels gap, they observe that some percentage of the 13.46 billion gallons of ethanol the economy was on pace to consume would be needed to fill the advanced biofuels mandate, leaving less than 13.46 billion to fill the 14 billion gallons of conventional biofuels that the economy would need to meet non-advanced biofuels portion of the total renewable mandate. *See, e.g.* Irwin & Good, *RFS with a 'Push' Strategy*, available at http://farmdocdaily.illinois.edu/pdf/fdd170615.pdf. EPA should take this additional observation from Good and Irwin into account when setting the final 2016 mandate.

[56] NPRM, 80 Fed. Reg. at 33,126.

Had EPA accounted for EIA's lower ethanol inclusion rate, it would have realized that the gap between EPA's mandate and the amount of renewable fuel that the economy was then on pace to use was not merely 840 million gallons, but nearly 1.1 billion gallons.[57]

B. EPA Cannot Rely on Significantly Increased E85 Usage to Meet its Mandates.

To fill the understated 840 million gallon gap for 2016 projected in the NPRM, EPA sketched out a variety of compliance scenarios that envision increased E85 usage, including as much as 600 million gallons in 2016. The notion that anywhere near these volumes can be supplied to consumers, beginning just six months from now and only one month after the Final Rule is scheduled to be promulgated, is highly speculative and ignores empirical evidence showing otherwise. Indeed, even after adjusting its own projections for 2015-2016 to account for the NPRM, EIA still concluded that it "does not expect measurable increases in E15 or E85 consumption over the forecast period."[58]

1. The evidence does not support EPA's theory that RIN prices will incentivize increased E85 usage by subsidizing high-ethanol fuels.

In order to bring about a significant increase in E85 usage, EPA has relied upon the theory that high RIN prices will help to "promote growth in renewable fuel supply."[59] In

[57] While EPA may point to more recent EIA projections based on the mandated volumes in the NPRM, the EIA projections predating the NPRM are a more useful proxy for calculating the gap between the volumes of renewable fuel the economy now must use to meet the 2016 mandates and what the economy most likely was on track to use prior to EPA's issuance of the NPRM. Further, as Irwin and Good's analysis underscores, even slight errors by EPA in its estimates and projections can significantly alter the mandates' impact on the economy. EPA has repeatedly shown it cannot reliably predict renewable fuel usage, and EIA projections of gasoline and diesel fuel usage also often miss the mark. This is all the more reason to aim conservatively when projecting the amount of renewable fuel that can be supplied to consumers in transportation fuel.

[58] U.S. Energy Info. Admin., *Short-Term Energy Outlook*, July 2015, at 33, http://www.eia.gov/forecasts/steo/report/renew_co2.cfm.

[59] NPRM, 80 Fed. Reg. at 33,129.

particular, EPA has emphasized that "high RIN prices can . . . provide the potential for reductions in the retail selling prices of E85 and E15 if distributors, blenders, and retailers pass the value of those RINs to end users."[60] Thus, EPA stated its "belie[f] [that] it is possible for the market to reach volumes *perhaps* as high as 600 million gallons *under favorable pricing conditions*" in 2016, while also suggesting even 800 million gallons of E85 usage is conceivable.[61] In support of this theory, EPA has offered a conceptual model suggesting that a blender selling RINs for 60 cents each in 2013 could have sold E85 to a fuel retailer for 43 cents less than it would have without the RFS program in place.[62] EPA has also theorized that even if retailers or blenders are profiting from the RIN price savings inherent in high-ethanol blends, rather than passing those savings onto consumers, such profit-taking behavior will eventually run its course and will bring about the infrastructure investments necessary to increase E85 usage. According to EPA: "By increasing the potential profitability of blending renewable fuels, higher RIN prices can incentivize the build out of the infrastructure necessary to blend and distribute renewable fuel blends as parties seek to enter or expand their position within this market."[63]

Unfortunately, however, EPA's theoretical model is belied by the empirical data. Economists Christopher Knittel, Ben Meiselman, and James Stock recently conducted an econometric analysis used to examine the transmission of RIN prices to national retail E85 fuel prices between January 1, 2013 and March 10, 2015. The economists found that the pass-through of RIN prices to the E85-E10 spread "*is precisely estimated to be zero* if one adjusts for

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[60] *Id.*

[61] *Id.* at 33,128 (emphasis added).

[62] U.S. EPA, *A Preliminary Assessment of RIN Market Dynamics, RIN Prices, and Their Effects*, EPA-HQ-OAR-2015-0111-0062 (June 10, 2015).

[63] 80 Fed. Reg. at 33,119; *see also id.* at 33,129 ("sustained high RIN prices create the incentives needed to spur investment in new technologies and production capacity, a critical need if the market is going to continue expanding in future years according to Congress' intentions.").

seasonality. . . ."[64] That is, far from moving the economy closer to achieving the "favorable pricing conditions" that EPA has deemed necessary to result in the usage of 400 to 600 million gallons of E85 in 2016, RIN prices had essentially *no* measurable effect on the price of E85 relative to E10 in the last two years. In summarizing their findings, Knittel, Meiselman, and Stock cast serious doubt on the notion that high RIN prices can incentivize greater E85 usage:

> [T]he most intriguing and challenging finding here is the near absence of pass-through of RIN prices to retail E85 prices. While RIN prices might be passed through at some retail outlets at some times, this is not the case on average using national prices. The goal of the RFS program is to expand the use of low-carbon domestic biofuels, and the key economic mechanism to induce consumers to purchase high-renewables blends is the incentives provided by RIN prices. If the RIN price savings inherent in blends with high biofuels content are not passed on to the consumer, *then this key mechanism of the RFS is not functioning properly*.[65]

In setting standards for 2016, EPA must account for this finding and what it suggests about the current RFS program's ability to bring about increased usage of renewable fuels.

The bottleneck that prevents the value of RINs from being passed through to consumers resides either with blenders or retailers, or some combination of the two. Although the NPRM tends to speak of blenders and retailers in the same breath,[66] in fact the two types of entities face very different economic incentives. If refiners were truly able to recover the price of RINs by raising the price of the blendstock they sell to blenders, then blenders should have a strong economic incentive to increase E85 sales. Doing so would maximize the ethanol subsidy from RINs and minimize the impact of increased blendstock prices. If reducing wholesale E85 prices

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[64] Knittel, et al., *The Pass-Through of RIN Prices to Wholesale and Retail Fuels under the Renewable Fuel Standard*, at 2 (emphases added), *available at* http://scholar.harvard.edu/files/stock/files/pass-through_of_rin_prices_1.pdf.

[65] *See id* at 20 (emphasis added).

[66] *See, e.g.*, NPRM, 80 Fed. Reg. at 33,129 ("High RIN prices can also provide the potential for reductions in the retail selling prices of E85 and E15 if distributors, blenders, and retailers pass the value of those RINs to end users.").

would incent greater wholesale E85 sales relative to E10 sales, then a blender could reduce its overall input costs by reducing the volume of blendstock it needed to deliver a blended product. Likewise, if reducing wholesale E85 prices would incent greater wholesale E85 sales, that would increase the number of RINs available for compliance, thereby reducing RIN prices and any RIN cost component impact on gasoline blendstock. Assuming lower E85 prices would meaningfully increase sales, a rational blender with retail operations also would have an incentive to build out infrastructure to increase E85 sales.[67] Indeed, a rational blender would have an incentive to profit-take on existing E85 sales only if it concluded that structural constraints beyond its control limit its ability to increase E85 sales over a reasonable time horizon.[68]

In light of the economic incentives facing blenders, fuel retailers are the more likely source of the bottleneck that prevents consumers from benefiting from lower E85 prices. E85 retailers face little competition and thus little downward pricing pressure on E85 prices. Of the 150,000 retail stations nationwide, only about two percent (or about 3,000 stations) offered E85 as of July 2015. Some of these stations may effectively enjoy a monopoly on E85 sales in their area. And, given EPA's own projections that the economy as a whole used less than 200 million

[67] To the extent blenders do not have such incentives, former Special Assistant to the President for Energy and Environment offers one explanation for this in support of his view that EPA must shift the RFS obligation form refiners to blenders. Specifically, he argues that integrated refiners with large marketing operations "are almost immediately long on RINs at the beginning of every compliance period" and therefore they have "little incentive to participate financially in the expansion of blending infrastructure to allow for higher level blends (E85 and E15) or additional advanced renewable fuels (B5-B20)." Comments of Ronald E. Minsk, EPA-HQ-OAR-2015-0111-1307, at 6-7 (Jul. 27, 2015). Mr. Minsk also observes that placing the obligation on refiners may actually create a *disincentive* to invest in higher blends or even blend to the blendwall, as "generation of fewer RINs could help them maximize their return on existing blending (E10)" since "meeting the mandate level decreases RIN profits generated from being a RIN-long party."

[68] To be sure, in such circumstances, a blender may still be forced to pass through the RIN value in wholesale E85 prices because overall competition in the blending markets may already suffice to drive E85 wholesale prices to cost. Of course, this is no help to EPA, since it merely means that the bottleneck resides at the retail level, where retail E85 stations can take profits on the RIN price savings inherent in high-ethanol blends, rather than passing those savings on to consumers.

gallons of higher ethanol blends in 2013 and 2014, it is likely that many of these E85 stations move little product. In the absence of competition from neighboring stations, these retailers have a strong incentive to pocket the RIN subsidy inherent in E85 rather than pass it through to their few E85 consumers through lower E85 prices.

Using the RFS program to change the incentives of fuel retailers is, to say the least, challenging and may well be impossible. The RFS program does not regulate the 150,000 or more mostly independent retail station owners. Between 96 and 99 percent of stations are owned by independent retailers, *i.e.*, retailers unaffiliated with major oil companies.[69] About 70 percent of retail outlets are convenience stores, which make most of their profit from merchandise such as food and beverages, and 58 percent of those are single outlet owners for whom the significant investment needed to sell E85 would be a major financial risk.[70] Most retail outlets also are not configured to provide an additional product like E85, because those outlets lack proper dispensers or a storage tank to handle it (and may not even have space for such tanks).[71] The notion that retailers will invest tens or even hundreds of thousands of dollars over the next six to

[69] PMAA letter to Chairman Upton and Ranking Member Pallone, House Committee on Energy and Commerce (May 1, 2015), http://www.pmaa.org/weeklyreview/attachments/PMAA_Rebuttal_RFA_April_2015_FINAL%20.pdf; Comments of Monroe Energy LLC and Philadelphia Energy Solutions Refining and Marketing LLC, EPA-HQ-OAR-2013-0479-5631 at 97 (Feb. 6, 2014) (citing exhibit 1, NERA Economic Consulting, *Analysis of RFS2 RIN Markets*, at 28 (Oct. 15, 2013) ("NERA Report")).

[70] See NACS, *2015 Retail Fuels Report*, at 29 (2015), http://www.nacsonline.com/YourBusiness/FuelsReports/2015/Documents/2015-NACS-Fuels-Report_full.pdf ("There are 127,588 convenience stores selling fuel in the United States, and these retailers sell an estimated 80% of all the fuel purchased in the country. Overall, 58% of the convenience stores selling fuel are single-store operators—more than 70,000 stores."); *see also* NERA Report at 28.

[71] NERA Report at 27-28.

eighteen months to offer what will remain a niche product—given the limited numbers of flex-fuel vehicles ("FFVs") and uncertain demand even among FFV owners—is highly speculative.[72]

Consider, for instance, E85 station data over the last 30 months of consistently high RIN prices. The data indicate that, even with consistently high RIN prices, infrastructure challenges have remained and likely will remain stubbornly in place for the near term. At the state level, observers often highlights Minnesota as an early adopter of E85, as the state is home to more E85 stations than any other.[73] Yet, even with consistently high RIN prices, Minnesota added only seven E85 stations in 2013, before *losing* 57 E85 stations in 2014, and another eight during the first five months of 2015.[74] On a national level, while there has been some growth in E85 stations, that growth is much slower than in years past and certainly far slower than what would be needed to meaningfully increase E85 market penetration by 2016. The U.S. Department of Energy's Alternative Fuels Data Center reported 2,498 public and private stations nationwide as of February 2012; 2,596 stations as of February 2013 (a 3.9 percent increase); 2,709 stations as of May 2014; (a 4.4 percent increase).[75] AFDC reports that there are only 2,944 stations as of July 2015 (a 8.7 percent increase), of which only 2,639 are actually open to the public.[76] That implies an average annual growth rate since 2012 of about 6 percent, less than half the historic

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[72] *Id.*

[73] *See, e.g.*, Fuels Institute, *A Market Performance Analysis and Forecast* (2014), http://www.fuelsinstitute.org/ResearchArticles/E85_AMarketPerformanceAnalysisForecast.pdf.

[74] Minn. Dep't of Commerce, *2015 Minnesota a E85 + Mid-Blends Station Report*, http://mn.gov/commerce/energy/images/2015-05may-e85.pdf.

[75] U.S. Dep't of Energy, *Transportation Energy Data Book*, ch. 6 (31st-33d eds.).

[76] U.S. Dep't of Energy, *Ethanol Fueling Station Locations*, http://www.afdc.energy.gov/fuels/ethanol_locations.html (last visited July 24, 2015).

annual growth rate.[77] EPA offers no explanation for why 30 months of high RIN prices led to slower growth in E85 stations, let alone why it anticipates the situation changing rapidly over the next six to 18 months to support the significant growth in E85 consumption it assumes in 2016.[78]

Thus, there is simply no empirical support for the notion that high RIN prices will lead retailers to pass on RIN price savings to customers in the form of lower E85 prices, especially within the next six to eighteen months. While EPA's economist hypothesizes that "high per-gallon profit margins [from profit taking] *may over time* result in new parties entering the E85 wholesale or retail marketplace, *and ultimately* greater competition and lower E85 fuel prices for customers," the available evidence does not support that tepid hypothesis.[79] EPA's apparent strategy is akin to crossing its fingers and hoping that higher RIN costs imposed on the first link in the fuel supply chain (*i.e.*, refiners) will meaningfully impact decision making in the last link of the chain (retail stations).

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[77] Fuels Institute, *A Market* Performance, at 33, http://www.fuelsinstitute.org/Research Articles/E85_AMarketPerformanceAnalysisForecast.pdf (reporting AFDC's historic growth rates as averaging 12.9 percent). The Fuels Institute in this 2014 report placed the number of E85 stations as between 2,600-3,400 stations. The higher figures reflect data provided by the ethanol industry—*i.e.*, Growth Energy (the reporting 2,804 stations) and the Renewable Fuels Association (then reporting 3,349 stations). *See id.* at 6. The Merchant Refiners Group believes that EPA should continue to rely on the statistics provided by the Department of Energy.

[78] Of course, EPA also ignores the fact that consumer awareness and acceptance of E85 is not simply a function of gasoline prices, or the number of FFVs or service stations. Market penetration of any new fuel, E85 included, will only grow over time and after sustained efforts each year to build consumer confidence in its safety and reliability. Additionally, EPA ignores the fact that projected growth in FFVs is flat, in no small part because subsidies for FFVs under the CAFE standards began to be phased out in 2011, creating a disincentive to produce FFVs and thereby potentially reducing their market penetration. *See, e.g.*, EIA, *Annual Energy Audit 2014 Early Release Overview* 4 (2013) ("FFVs are necessary to meet the renewable fuels standard (RFS), but the phase-out of corporate average fuel economy (CAFE) credits for their sale, as well as limited demand from consumers, reduces their market penetration.").

[79] EPA-HQ-OAR-2015-0111-0062 at 26 (emphasis added). Indeed, consider the caveats the same economist places on what EPA may conclude from limited evidence in Iowa: "[The data] further supports EPA's argument that, *if all else remains equal*, rising RIN prices *may impact* the relative pricing of fuel blends containing differing amounts of renewable fuel . . . ." *Id.*

2. *EPA has overestimated E85 usage for 2016.*

Because EPA cannot expect high RIN prices to incent meaningful E85 growth in 2016, it should assume no more than 100-200 million gallons of E85 usage in 2016. EPA concluded in the NPRM that the market produced about 130 million gallons of E85 in 2013, and that E85 *and* E15 usage was "only about 100-200 million gallons" in 2014. Yet EPA did not provide any evidence to support these estimates and, as explained below, production data on which EPA has previously relied suggest that EPA has significantly overstated E85 consumption in past years.

EPA identified two EIA data sources to support E85 estimates and projections in connection with the original 2014 NPRM (although not even these sources supported those estimates and projections). Revisiting those data sources reveals production of 50.3 million gallons in 2012, 64.6 million gallons in 2013, and only about 76.5 million gallons in 2014. Production thus grew annually by only 18 to 28 percent over the last 30 months, despite high RIN prices, and production has not yet reached the 100 million gallon mark in any year. The data also reflect two-year growth (2012-2014) of only 52 percent. However, to reach the levels of E85 usage assumed in twelve of the sixteen compliance scenarios that EPA has identified in the NPRM, production would have to jump from 2014 levels by between 161 to 684 percent (i.e., from 76.5 million gallons to 200-600 million gallons). E85 production in 2015 has also remained low. Year-to-date E85 production data for 2015 show that E85 production during the first four months reached only 21.34 million gallons, as compared to 21.42 million gallons over the same period in 2014.[80] In other words, E85 production has actually *decreased* from 2014

[80] U.S. Energy Info. Admin., *U.S. Renewable Fuel & amp; Oxygenate Plant Net Production of Finished Gasoline*, http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=M_EPM0F_YNP_NUS_MBBL&f=M (last visited July 22, 2015); U.S. Energy Info. Admin., *U.S. Refinery and Blender Production of Motor Gasoline, Finished, Conventional, Greater than Ed55*,

levels. Even if production improves over the remaining quarters, so that 2015 production increases by an aggressive 25 percent over 2014 levels (*i.e.*, about 95.6 million gallons in 2015), E85 consumption would still need to more than double in 2016 to reach 200 million gallons.[81] There is no empirical foundation for projecting such significant growth.

Moreover, even taking EPA's higher numbers on faith and assuming that the economy consumed about 160 million gallons of E85 in 2014,[82] the resulting growth rate between 2013 and 2014 was only about 23 percent. Applying that growth rate over the next two compliance periods yields only about 197 million gallons of E85 in 2016, still well below what EPA assumes in half of its compliance scenarios for 2016. Of course, that growth rate ignores the low end of EPA's 2014 range, which, if used, would imply a *negative* growth between 2013 and 2014, and would undermine any suggestion that the economy could consume 200 million gallons in 2016.

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http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=M_EPM0CAG55_YPR_NUS_MBBL&f=M (last visited July 22, 2015).

[81] State-level data from Minnesota further demonstrate that E85 usage remains low, with only modest overall growth in the past two years. Because Minnesota has the highest concentration of E85 sales in the country, it should experience the most significant per capita growth in E85. However, estimated E85 sales volumes of 18.12 million gallons in 2013 represent modest annual growth of about 23 percent compared to 2012 estimated volumes (sales reported in the Minnesota Dept of Revenue Petroleum Collections Report ("MNDDR") were lower, at only 13 million gallons in 2013). Minn. Dep't of Commerce, *2015 Minnesota a E85 + Mid-Blends Station Report*, http://mn.gov/commerce/energy/images/2015-05may-e85.pdf. Estimated E85 sales then *decreased* in 2014 to about 16.5 million gallons, even with persistently high RIN prices (MNDDR *reported* sales equaled only 13.4 million gallons, reflecting very modest annual growth). *See id*. Sales figures for the first five months of 2015 reflect modest year-over-year growth from 2013 levels (estimated and MNDDR consumption declined 1.4 percent, and increased 33.6 percent, respectively), and significant negative growth from 2014 levels (estimated and MNDDR consumption fell by 18.4 and 5.6 percent, respectively). *See* Minn. Dep't of Commerce, *2014 Minnesota a E85 + Mid-Blends Station Report*, http://mn.gov/commerce/energy/images/2014_12DecE85.pdf; Minn. Dep't of Commerce, *2013 Minnesota a E85 + Mid-Blends Station Report*, http://mn.gov/commerce/energy/images/E85-2013.pdf.

[82] EPA estimates E15 usage at 40 million gallons in 2014. While the Merchant Refiner Group takes no position on the accuracy of those figures, it deducts that volume here from EPA's 100-200 million gallon range for E15 and E85 to arrive at its 160-million gallons example for E85.

C. In Order to Satisfy EPA's Proposed Mandates, Biomass-Based Diesel Consumption Would Need to Increase to Levels That EPA Has Said Are Merely "Theoretically" Possible.

EPA purported to set the biomass-based diesel mandate at 1.8 billion physical gallons in 2016, about 200 million physical gallons more than were available for compliance a mere six months ago.[83] But the effective biomass-based diesel mandate proposed for 2016 is actually much higher. Even if E85 consumption were to grow robustly over the next six months so that the market has the capacity to use 100-200 million gallons in 2016, Table II.D.2-2 suggests that the market still must also use approximately 2.0-2.1 billion physical gallons of biomass-based diesel in order to achieve the proposed mandates.[84] There is a substantial risk that the market will come up short in meeting EPA's goal. Moreover, by imposing standards that require biomass-based diesel production to be pushed to the limits of what is practicable and then beyond those limits, EPA will cause significant volatility in RIN prices. Accordingly, EPA must revise its advanced and total renewable mandates downward to more realistic levels.

1. *EPA effectively proposed to mandate consumption of biomass-based diesel at levels at or near what EPA describes merely as "theoretically possible"*

According to EPA, the market made available for compliance about 1.63 billion physical gallons of biomass-based diesel last year, slightly more than the 1.55 billion physical gallons made available in 2013.[85] Thus, to meet EPA's effective mandate for biomass-based diesel of about 2.0-2.1 billion gallons over the next six to eighteen months, the economy would need to increase the number of physical gallons available for consumption by about 20 to 29 percent

[83] NPRM, 80 Fed. Reg. at 33,133.

[84] *Id.* at 33,127 and 33,128.

[85] NPRM, 80 Fed. Reg. at 33,133.

compared to last year. Yet year-over-year production through the first six months of 2015 has increased only by 16 million physical gallons, or 2 percent compared to this time last year.[86]

The notion that the biomass-based diesel production can reach about 2.0-2.1 billion physical gallons in 2016 also is in tension with EPA's previous acknowledgement that structural impediments prevent the industry from quickly and materially increasing domestic production, which amounted to only 1.46 billion of the 1.63 billion gallons available for compliance in 2014.[87] EPA should have concluded from that earlier analysis—which EPA relied upon for its exercise of waiver authority—that it is unrealistic to achieve biomass-based diesel production of 2.0-2.1 billion gallons within six to eighteen months. Instead, EPA relied on its calculation that more than 2.7 billion gallons of *capacity* has been registered at one time or another under the RFS program.[88] But the mere existence of capacity that at one time has been registered says very little about the market's *actual* ability to increase domestic production over the next six to eighteen months to make an additional 322 million gallons or more available.[89]

EPA likewise observed that there are more than sufficient feedstocks to produce 2.1 billion gallons of biodiesel.[90] It suggested that "[i]t is possible that the market could divert additional feedstocks from food and other domestic uses or exports to the production of

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[86] *Compare* U.S. EPA, 2015 RFS2 Data, http://www.epa.gov/otaq/fuels/rfsdata/2015emts.htm (last visited July 24, 2015) *with* U.S. EPA, 2014 RFS2 Data, http://www.epa.gov/otaq/fuels/rfsdata/2014emts.htm (last visited July 24, 2015).

[87] NPRM, 80 Fed. Reg. at 33,128.

[88] *Id.*

[89] This figure is derived by using the minimum incremental gallons of biomass-based diesel that EPA posits would be needed to meet the total mandate in the event that the economy consumed no more than 200 million gallons of E85 (i.e., 1,952 billion physical gallons).

[90] *Id.*

biodiesel,"[91] noting that the market theoretically could have foregone exporting 690 million gallons of feedstocks. But EPA did not assess whether that degree of diversion is achievable in practice, particularly if much of that feedstock is committed to feeding populations or to other productive uses that may not be easy to abandon on a dime.

Indeed, EPA acknowledged that such increased biomass-based diesel production may not be practically achievable. In its own words, EPA was "not able to say whether [2.131 billion physical gallons] of BBD is one that the market could be expected to achieve in 2016, notwithstanding our belief that such volumes *are theoretically possible*."[92] If EPA believes producing 2.131 billion physical gallons in 2016 is only *theoretically possible*, what basis has it to believe other targets between 1.952 and 2.065 billion gallons (i.e., the remaining portion of the range posited in the event E85 consumption reaches 100-200 million gallons) are *actually possible*? EPA must revise its advanced and total renewable requirements to levels that can *actually* be achieved with some reasonably degree of certainty.

2. EPA has ignored additional factors that could constrain the economy's ability to consume biomass-based diesel at the levels needed to meet the proposed mandates.

Not only has EPA set an effective biomass-based diesel mandate at a level that by its own admission is only theoretically possible, and not necessarily achievable in practice, it has also ignored important market risks that may make its effective mandate impracticable. For example, EPA has ignored the possibility that diesel consumption will outstrip EIA projections for 2016. If total diesel usage projections turn out to be too low, then more physical gallons of biomass-based diesel will be needed to achieve the same fractional advanced and total renewable requirements. Yet its proposed mandates, based upon current EIA gas and diesel projections,

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[91] *Id.*

[92] *Id.* at 33,129.

already push biomass-based diesel production to levels that are only theoretically achievable. EPA appears not to have considered this possibility in setting advanced and total requirements. It should adjust mandates to provide more breathing room to meet the requirements with production in 2016.

EPA also has understated the role biomass-based diesel may have to play in filling the renewable gap by assuming the market will produce 206 million gallons of cellulosic biofuel.[93] If EPA projections of cellulosic production miss the mark, then even with robust E85 growth, biomass-based diesel markets may have to make closer to 2.2-2.3 billion gallons available for compliance. This scenario is in fact likely given EPA's terribly poor track record in projecting cellulosic production—it has been off by millions of gallons in each of the last several years.[94]

3. The statute bars EPA from setting advanced and total volume requirements premised on the production of a greater volume of biomass-based diesel than EPA has found appropriate to require under Section 7545(o)(2)(B)(ii).

Even if the economy were capable of producing biomass-based diesel in the volumes that would be needed to comply with EPA's proposed advanced and total mandates, EPA would still be prohibited from setting volume requirements premised on that level of biomass-based diesel production. Congress specifically carved biomass-based diesel production out of the general RFS program for years following 2012, and has required EPA to decide on the "applicable

[93] *Id.* at 33,127.

[94] EPA might respond that it could address that sort of issue later—once it is clear the cellulosic industry cannot perform up to EPA's aspirational projections, EPA could reduce the advanced and total renewable volume requirements at that time. But that does not justify leaving the market to guess whether it must consume at least 170 million more gallons of biodiesel. And, as EPA recognizes, "changing those requirements during the compliance year . . . would be disruptive to businesses and therefore to the long-term objectives of the RFS program . . . ." *Id.* at 33,130.

volume" of biomass-based diesel based on consideration of six specific factors.[95] These include factors evidencing Congress' concern that excessive production may cause environmental harm. For example, EPA is directed to consider "the impact of the production and use of renewable fuels on the environment, including on air quality, climate change, conversion of wetlands, ecosystems, wildlife habitat, water quality, and water supply."[96] Congress also charged EPA to consider the "impact of the use of renewable fuels on other factors, including job creation, the price and supply of agricultural commodities, rural economic development, and food prices."[97] Likewise, Congress recognized that an excessive biomass-based diesel requirement could cause economic harm. Thus, Congress directed EPA to consider "the impact of renewable fuels on the infrastructure of the United States, including deliverability of materials, goods, and products other than renewable fuel, and the sufficiency of infrastructure to deliver and use renewable fuel."[98] EPA also must consider "the impact of the use of renewable fuels on the cost to consumers of transportation fuel and on the cost to transport goods."[99]

Applying these factors and the others listed in the relevant statutory subsection, EPA concluded that the "applicable volume" of biomass-based diesel for 2016 is 1.63 billion gallons.[100] Having so determined, EPA cannot then set volume requirements for advanced and total renewable fuels that contemplate the need for biomass-based diesel in excess of that amount, without regard to any of the statutory factors. Yet that is exactly what EPA has done –

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[95] *See* 42 U.S.C. § 7545(o)(2)(B)(ii)(I)-(VI).

[96] *Id.* § 7545(o)(2)(B)(ii)(I).

[97] *Id.* § 7545(o)(2)(B)(ii)(VI).

[98] *Id.* § 7545(o)(2)(B)(ii)(IV).

[99] *Id.* § 7545(o)(2)(B)(ii)(V).

[100] NPRM, 80 Fed. Reg. at 33,136.

thereby circumventing the carefully channeled discretion that Congress afforded to EPA in setting biomass-based diesel volumes in the years subsequent to 2012.

D. EPA Has Relied on Flawed Estimates of Other Biofuels Production in Projecting Compliance Scenarios for 2016.

While EPA has focused primarily on the role of E85 and biomass-based diesel in filling the underestimated 840-million gallon renewable gap for 2016, EPA has also assumed in most scenarios that the economy will consume several hundred million gallons of other advanced and conventional biofuels. EPA has claimed that the estimated consumption ranges for these other biofuels in its scenarios are generally consistent with ranges achieved over the last several years. However, other data relied upon by EPA suggest those ranges may be too high.

Thirteen of EPA's sixteen scenarios for 2016 assume the economy will consume 125 million or more physical gallons of conventional biodiesel, and all but five of those scenarios assume that the economy will consume 250 million gallons. EPA stated in the NPRM that 250 million gallons of conventional (D6) biodiesel is only "slightly higher" than the 225 million gallons imported in 2014. EPA apparently derived 2014 levels from data showing the economy imported 53 million gallons of conventional biodiesel and 151 million gallons of conventional renewable diesel. Yet the data call that story into question. Specifically, a document entitled "2014 RIN Supply" reflects a 146 million gallon "correction" to the reported 151 million gallons of conventional renewable diesel imported in 2014.[101] That correction results in only 5 million of the reported 151 million physical gallons of conventional renewable diesel being available for compliance. A similar pattern appears upon review of a separate document entitled "2013 RIN

[101] EPA, 2014 RIN Supply, Supporting & Related Material, EPA-HQ-OAR-2015-0111-0004 (June 10, 2015).

Supply."[102] Specifically, that document reflects a 63 million gallon "correction" to the reported 116 million gallons of conventional renewable diesel imported in 2013.[103] That correction results in only 53 million of the reported 116 million physical gallons being available for compliance. EPA should explain why it appears not to have used "corrected" figures to derive estimates of the amount of conventional diesel available for compliance in 2016.

In any event, EPA's assumption that usage of that biofuel will increase in 2016 is in tension with its observation that consumption levels for each biofuel in its sixteen scenarios depends on the level of consumption of other biofuels in those scenarios. Specifically with respect to conventional biodiesel, EPA observed that "greater BBD production reduces the likelihood of large imports of palm biodiesel because these two fuels compete against one another." Yet, even in scenarios where EPA assumed biomass-based diesel consumption of nearly 2.1 billion gallons, EPA still assumed maximum conventional biodiesel consumption of 250 million gallons.

There is another problem concerning EPA's projections of conventional biodiesels—specifically, with respect to palm-based biofuels. EPA has declined to approve those biofuels as an eligible feedstock to generate RINs under RFS2 because they fail to meet the greenhouse gas reduction standards of the RFS program. The only reason palm oil imports contribute to the RFS program in the first place is because EPA grandfathered a handful of plants able to continue using the feedstock to produce D6 RINs.[104] Adopting mandates that encourage use of biofuels

[102] EPA, 2013 RIN Supply, Supporting & Related Material, EPA-HQ-OAR-2015-0111-0003 (June 10, 2015).

[103] *See id*.

[104] Platts, *US biodiesel imports in July hit year-to-date high: Census Bureau* (Sept. 4, 2014), http://www.platts.com/latest-news/shipping/montreal/us-biodiesel-imports-in-july-hit-year-to-date-21183120.

with questionable environmental properties—such as palm-based diesel—makes little sense and, indeed, is contrary to the statutory purpose of the RFS program.

In 13 of its 16 compliance scenarios, EPA has also assumed that usage of "other non-ethanol advanced" biofuels will be between 50 and 100 million gallons, an assumption that is based "on the range of volumes achieved over the last several years."[105] Yet 2014 RIN supply data reveal that "other non-ethanol advanced" biofuels contributed only 53 million gallons in 2014, a very steep decline from the 93 million gallons made available for compliance in 2013.[106] EPA has failed to explain the basis for its assumption that use of these biofuels will now grow by up to 89 percent from 2014 levels. Nor has EPA addressed the fact that, through the first six months of 2015, production is only about 16.9 million ethanol equivalent gallons.[107] Even if one arbitrarily assumed double that growth over the remaining six months of 2015, "other non-ethanol advanced" biofuels would contribute only about 50.7 million ethanol-equivalent gallons, representing a *decline* from 2014 levels.

Finally, eleven of sixteen of EPA's compliance scenarios assume the economy will consume between 102 million and 433 million gallons of sugarcane ethanol in 2016. As EPA observed, imports fell from 435 million gallons in 2013 to 64 million gallons in 2014, a trend expected to continue in 2015 now that the economy has reached the E10 blendwall and the Brazilian government has granted an expected increase in the required ethanol content of gasoline from 25 percent to 27.5 percent.[108] Indeed, six months into the year, it appears the

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[105] NPRM, 80 Fed. Reg. at 33,127.

[106] EPA-HQ-OAR-2015-0111-0004.

[107] U.S. EPA, 2015 RFS2 Data, http://www.epa.gov/otaq/fuels/rfsdata/2015emts.htm.

[108] NPRM, 80 Fed. Reg. at 33,116.

economy has imported slightly less than 11 million gallons of sugarcane ethanol.[109] In light of this, even if EPA can point to certain projections that Brazilian ethanol will recover, it is more prudent to cap consumption in its scenarios at closer to the current level of observed imports.

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In sum, EPA not only has decided to push the very boundary between adequate and inadequate supply, but has then adopted unrealistic and overly optimistic projections of where that boundaries lies. It is incumbent upon EPA to address all of these trends directly and to adjust the size of its renewable mandates for 2016 accordingly. It is no answer that parties can rely on carryover RINs to cover any deficit, in the event that EPA's projections turn out to be too optimistic. As discussed above, EPA has made clear that carry-over RINs serve an important role in buffering the industry against unexpected occurrences like crop failures. They are not designed to cover RIN shortfalls resulting from overly ambitious volume requirements. Indeed, as EPA itself has acknowledged, now that the economy has reached the E10 blendwall, any reduction in the number of carryover RINs is likely to be irreversible. Given that reality, and the fact that RIN stocks already are only half as large as EPA deemed prudent when it established the RIN program, it is imperative that EPA not look to carryover RINs as a backstop compliance mechanism for overly aggressive, unachievable volume requirements.

E. The Merchant Refiners Group Supports the Timetable Proposed by EPA for Demonstrating Compliance for 2013-15.

EPA has proposed "that compliance demonstration reports for obligated parties be submitted no later than January 31, 2016 for the 2013 compliance year, June 1, 2016 for the 2014 compliance year, and December 1, 2016 for the 2015 compliance year. Associated attest engagement reports would be due no later than June 1, 2016 for the 2013 compliance year,

[109] U.S. EPA, 2015 RFS2 Data, http://www.epa.gov/otaq/fuels/rfsdata/2015emts.htm.

December 1, 2016 for the 2014 compliance year, and June 1, 2017 for the 2015 compliance year."[110] The Merchant Refiners Group supports EPA's proposed timeline for demonstrating compliance and agrees with EPA that "this sequencing of reports, and the time allowed between them will allow obligated parties to proceed in a logical and orderly fashion to submit required reports, with sufficient intervening time so as not to pose an unreasonable burden."[111] A more compressed timeline could adversely impact the RIN market and result in price volatility.

III. EPA MUST MOVE THE COMPLIANCE OBLIGATION TO BLENDERS IF RINS ARE TO INCENT CONSUMPTION OF HIGH-ETHANOL BLENDS.

As discussed above, EPA has theorized that the RFS program will result in lower retail prices for E85, subsidizing the cost of E85 relative to fuels that do not contain a large percentage of renewable fuel, and thereby incenting great E85 consumption.[112] EPA posited in the NPRM that RIN prices paid by obligated parties will "decrease the effective cost of renewable fuel used to create transportation fuel."[113] This, in turn, is theorized to result in lower retail prices for high-ethanol blends relative to E10. As EPA explained: "[C]ompetition among renewable fuel blenders and distributors should result in a greater portion of the reduced effective cost of renewable fuel blends enabled by the sale of the RIN to be passed on to fuel consumers."[114]

Unfortunately, as discussed above, reality does not reflect EPA's theory. Empirical evidence during a two-year period of high RIN prices reveals that the value of RINs are *not* being passed through to retail customers in the form of lower relative E85 prices nationwide.[115]

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[110] NPRM, 80 Fed. Reg. at 33,149.

[111] *Id.*

[112] *Id.* at 33,119.

[113] *Id.*

[114] *Id.*

[115] *See supra* at 21-27.

Likewise, even after adjusting projections for 2015 and 2016 to account for the NPRM, EIA still "does not expect measurable increases in E15 or E85 consumption over the forecast period."[116] That is a major problem for EPA's plan to use RIN prices to stimulate E85 consumption. To the extent EPA wishes to achieve steadier, more robust growth in E85 consumption, EPA must find a way to break through the bottleneck identified by Knittel, Meiselman, and Stock that prevents RIN values from being passed through to consumers in the form of lower E85 prices.

As an initial step toward a solution, EPA should move the compliance obligation away from refiners and importers and should place that obligation on blenders.[117] The parties on whom EPA continues to impose the compliance obligation—refiners and importers—are the worst situated to encourage blenders or retailers to pass along the value of RINs to the ultimate consumer. Refiners—particularly merchant refiners—have little to no control over the retail markets for biofuels. They own about 4 percent or less of the retail stations,[118] do not contract directly with them, and do not otherwise exercise much influence over the decision-making of these downstream market players. The NPRM ignored this reality. It suggested obligated parties might meet the 2016 mandates by "[d]eveloping contractual mechanisms to ensure favorable

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[116]U.S. Energy Info. Admin., *Short-Term Energy Outlook*, July 2015, http://www.eia.gov/forecasts/steo/report/renew_co2.cfm.

[117] Monroe notes that, for over a year and a half, it has had a petition for rulemaking pending on this issue. EPA has not acted on that petition. Monroe has also filed a petition for review in the D.C. Circuit on this issue, which has been held in abeyance pending EPA's action on the petition for rulemaking. *See* Respondent EPA's Status Report, at 3, *Monroe Energy, LLC v. EPA.*, Case No. 14-1014 (D.C. Cir. Apr. 30, 2015), Doc. No. 1550049 ("At this time, EPA continues to evaluate the issues raised in Monroe's administrative petition, but has not yet taken final action on that petition. EPA's next status report to the Court is due on Wednesday, July 29, 2015.").

[118] *See* PMAA letter to Chairman Upton and Ranking Member Pallone, http://www.pmaa.org/weeklyreview/attachments/PMAA_Rebuttal_RFA_April_2015_FINAL%20.pdf.

pricing of E15 and E85 at retail compared to E10 to boost sales volumes."[119] That makes little sense for obligated parties who generally have no relationships whatsoever with retailers. EPA is directing its advice to the wrong link in the supply chain. "Refiners are in no position to ensure, or even contribute to, growth" in the supply of renewable fuels to consumers.[120]

It is important to recall again that EPA's decision to regulate the very first link in the chain was driven by little more than administrative convenience. The RFS1 Rulemaking placed the obligation "on the relatively small number of refiners and importers rather than on the relatively large number of downstream blenders and terminals in order to minimize the number of regulated parties and keep the program simple."[121] EPA acknowledged in 2010 that the rationale that originally justified imposing the compliance obligation on refiners and importers was "no longer valid."[122] Yet when the agency last examined the issue in 2010, it found no pressing reason to alter course and decided to leave its rule unchanged. But the Agency pledged to revisit the issue if the RIN market did not operate as intended, which the empirical evidence shows is now the case. It is therefore time for EPA to make good on its promise to revisit its 2007 decision to place the obligation on refiners.

Administrative convenience is no longer a justification for inaction. There is no benefit to continuing to impose the compliance obligation on the parties the worst situated to encourage greater consumption of high-ethanol blends. By contrast, switching the obligation to blenders has the potential to significantly impact the price of high-ethanol blends to retail consumers.

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[119] NPRM, 80 Fed. Reg. at 33,129.

[120] *Am. Petroleum Inst.*, 706 F.3d at 480.

[121] 2010 Rule, 75 Fed. Reg. at 14,722.

[122] *See id.*

James Stock, one of the authors of the recent study finding no meaningful pass through of RIN values to retailers nationwide, published a paper this past April explaining that shifting the obligation from refiners to blenders could improve the RFS program's ability to subsidize high renewable-content fuels, such as E85. According to Professor Stock, placing the RFS obligation on blenders rather than refiners could help the economy overcome the E10 blendwall. As he explains, "because blenders either are retailers or sell to retailers, blenders are better situated to pass the RIN subsidy for high-renewable content fuels along to the consumer than are the current obligated parties, who are further upstream."[123]

To the extent blenders are the bottleneck, EPA could eliminate profit-taking behavior by eliminating the profit source—*i.e.*, the ethanol subsidy they receive from selling RINs to refiners. By replacing an indirect ethanol subsidy with a direct RFS obligation, EPA would increase blenders' incentives to competitively price E85 and to place pressure on affiliated or non-affiliated retailers to do so as well. While blenders appear to have that incentive now, blenders with greater capacity to absorb RIN costs in blendstock prices may not feel the cost impact nearly as significantly as they would if they had to report it on their balance sheet.

To the extent retailers are the bottleneck, declining to pass along the RIN subsidy to retail customers, blenders again are in a better position than refiners to exert financial pressure, or else to work in cooperation with retailers (and perhaps EPA) to expand retail competition for E85.

What is more, there is no apparent downside to EPA shifting the obligation closer to the current bottleneck preventing greater E85 consumption. Indeed, doing so would also remove a major inefficiency in the current regulatory scheme. RFS places on refiners an unnecessary

[123] James H. Stock, *The Renewable Fuel Standard: A Path Forward*, Columbia/SIPA Center on Global Energy Policy, April 2015, at 29, *available at* http://energypolicy.columbia.edu/sites/default/files/energy/Renewable%20Fuel%20Standard_A%20Path%20Forward_April%202015.pdf (attached as Exhibit B).

degree of price risk in the highly illiquid secondary markets for RINs. As Knittel, Meiselman, and Stock explain, "[e]ven with full pass-through, however, an obligated party could face RIN price risk because of timing differences between when the RIN obligation is incurred and when RINs are acquired."[124] As Professor Stock further notes: "The purpose of the RIN system is to ensure compliance with the RFS, not to add price risk to the balance sheets of obligated parties that happen to have a . . . mismatch" between the number of RINs they generate and the number that they must retire.[125] Given that refiners are less able than blenders to control how much E85 is consumed and at what price, it is a mystery why EPA believes refiners should bear that market risk, especially as it appears to be accomplishing nothing of value to the environment.

Continuing the policy of placing the compliance obligation on refiners is even more misguided to the extent that refiners are unable to pass through the cost of RINs to blenders in higher blendstock prices. In such circumstances, the RFS program merely imposes a tax on refiners, and that tax does not promote any increase in renewable fuel usage by consumers. In fact, the empirical evidence demonstrates a weak correlation between BOB spreads and RIN prices within and among certain regional markets, indicating that refiners are not able to pass on the full cost of the RINs they must procure for compliance.[126] And empirical research to date on whether refiners are able to pass through RIN costs in blendstock prices is limited in important

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[124] Knittel, et al., *The Pass-Through of RIN Prices to Wholesale and Retail Fuels under the Renewable Fuel Standard*, at 20, http://scholar.harvard.edu/files/stock/files/pass-through_of_rin_prices_1.pdf.

[125] Stock, *The Renewable Fuel Standard: A Path Forward*, at 29, http://energypolicy.columbia.edu/sites/default/files/energy/Renewable%20Fuel%20Standard_A%20Path%20Forward_April%202015.pdf.

[126] For example, Knittel, Meiselman's regression coefficient for NY RBOB-Brent is 0.684 with a standard error of 0.332, revealing a relatively weak correlation. *See* Knittel et al., *The Pass-Through of RIN Prices to Wholesale and Retail Fuels under the Renewable Fuel Standard*, Table 2, at 31, http://scholar.harvard.edu/files/stock/files/pass-through_of_rin_prices_1.pdf. The coefficient for Los Angeles RBOB-Brent is only 0.720 with a 0.704 standard error. *Id.*

respects. For instance, the Merchant Refiners Group is aware of no study evaluating the correlation between BOB spreads and RIN prices in the Gulf Coast or Midcontinent. These regions differ from others, such as New York Harbor, a market which is short on BOB and relies on imports to balance supply and demand, creating opportunities for foreign and national suppliers alike to recoup RIN costs. The Gulf Coast or Midcontinent regions, by contrast, are relatively long on BOB and export significant quantities. As others argue in comments, that market dynamic—where BOB suppliers compete in a buyer's market (indeed, an export market) and thus are price-takers—makes it much more difficult for merchant refiners to competitively price BOB to recoup their high RIN costs. EPA must carefully study this possibility, not only because commenters offer preliminary data supporting it, but also because the Merchant Refiners Group understands these regions account for 50 percent or more of the nation's refining capacity.

If merchant refiners cannot recover RIN costs (or only partially recover those costs), as the Merchant Refiners Group has argued previously, the principal effect of higher RIN prices is simply a massive transfer of wealth from refiners who need RINs to any parties holding such RINs, as well as a distortion of the refining market to the detriment of merchant refiners. The RIN system was never intended to artificially tilt the competitive market in favor of one group of obligated parties and against another. To the contrary, it was specifically intended to facilitate compliance by obligated parties in a competitively neutral and environmental beneficial way.[127]

In the end, if EPA is serious about using the RFS to subsidize high renewable-content fuels such as E85, it must shift the obligation closer to the bottleneck.[128] Even if EPA thinks it is

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[127] As EPA explained when implementing the RIN program, Congress mandated implementation of the RFS through a tradable credit system in order to "preserve[] the natural market forces and blending practices that will keep renewable fuel costs to a minimum." 72 Fed. Reg. at 23,929.

[128] Indeed, Mr. Minsk observes that switching the obligation to blenders may more cost-effectively incent consumption of higher blends of biodiesel. Specifically, he observes that the

too late to do so for 2016, there are still six long years left in the program after that. EPA should not continue to "appl[y] the pressure to one industry (the refiners), . . . [when] it is another … that enjoys the requisite expertise, plant, capital and ultimate opportunity for profit."[129]

Indeed, shifting the compliance obligation from refiners to blenders will remain important even if EPA chooses, for 2017 and beyond, to impose standards based on a projection of "the share of the fuel pool that can reasonably be expected to be comprised of renewable fuel over time."[130] EPA has suggested that adopting standards based on the share of renewable fuel in the fuel pool would provide clearer market signals and greater certainty, helping to foster greater investment in the infrastructure needed to increase consumer demand for higher-ethanol blends. However, refiners and importers, which sit at the top of the supply chain and typically have no direct relationship to fuel retailers, are simply not well-situated to make such investments. Unless EPA shifts the compliance obligation to parties closer to the consumer, it will achieve little growth in renewable fuel usage, regardless of whether standards are set based on a share of the fuel pool or total volumes.

Accordingly, EPA should shift the compliance obligation to the parties best situated to encourage increased usage of renewable fuel.

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cost of investing in biodiesel infrastructure is significant and that, "[b]ecause not all customers are in need of RIN generation, critical consensus for investing may never mature. This can delay or foreclose the necessary investments in biodiesel infrastructure. This would not happen if all of the users of the terminal were equally obligated." Comments of Ronald E. Minsk, EPA-HQ-OAR-2015-0111-1307, at 7.

[129] *Am. Petroleum Inst.*, 706 F.3d at 480. *See also* EPA-HQ-OAR-2015-0111-1307, at 3 ("EPA's current view is that the parties facing ever increasing costs for RINs will be incentivized to build new infrastructure or to invest in blending operations. . . .This is akin to telling a product's manufacturer that it also must become its distributor. Stated differently, EPA expects that RIN pricing will become so severe, that it will reverse the last 20 years of de-integration in the refinery industry.").

[130] *See* NPRM, 80 Fed. Reg. at 33,109.

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EXHIBIT A

The Pass-Through of RIN Prices to Wholesale and Retail Fuels under the Renewable Fuel Standard

June 2015

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Extended Abstract

The U.S. Renewable Fuel Standard (RFS) requires blending increasing quantities of biofuels into the U.S. surface vehicle fuel supply. In 2013, the fraction of ethanol in the gasoline pool effectively reached 10%, the ethanol capacity of the dominant U.S. gasoline blend (the "E10 blend wall"). During 2013-2015, the price of RINs—tradeable electronic certificates for complying with the RFS—fluctuated through a wide range, largely because of changes in actual and expected policy combined with learning about the implications of the E10 blend wall. RINs are sold by biofuels producers and purchased by obligated parties (refiners and importers), who must retire RINs in proportion to the petroleum they sell for surface transportation. As a result, RINs in effect serve as a charge on obligated fuels and a corrective subsidy for lower-carbon renewable fuels, and are neutral for fuels outside the RFS. In theory, RIN prices provide incentives to consumers to use fuels with a high renewable content and to biofuels producers to produce those fuels, and as such are a key mechanism of the RFS.

This paper examines the extent to which RIN prices are passed through to the price of obligated fuels, and provides econometric results that complement the graphical analysis in Burkholder (2015). We analyze daily data on RINs and fuel prices from January 1, 2013 through March 10, 2015. When we examine wholesale prices on comparable obligated and non-obligated fuels, for example the spread between diesel and jet fuel in the U.S. Gulf, we find that that roughly one-half to three-fourths of a change in RIN prices is passed through to obligated fuels in the same day as the RIN price movement, and this fraction rises over the subsequent few business days. Using six different wholesale spreads between obligated and non-obligated fuels, we estimate a pooled long-run pass-through coefficient of 1.01 with a standard error of 0.12.

We also examine the transmission of RIN prices to retail fuel prices. The net RIN obligation on E10 is essentially zero over this period, and indeed we find no statistical evidence linking changes in RIN prices to changes in E10 prices. We also examine the price of E85 which, with an estimated average of 74% ethanol, generates more RINs than it obligates and thus in principle receives a large RIN subsidy. In contrast to the foregoing results, which are consistent with theory, the pass-through of RIN prices to the E85-E10 spread is precisely estimated to be zero if one adjusts for seasonality (as we argue should be done), or if not, is at most 30%. Over this period, on average high RIN prices did not translate into discounted prices for E85.

JEL codes: Q42, C32

Key words: fuels markets, energy prices, E85, RBOB, wholesale fuel spreads, retail fuel spreads

1. Introduction

The U.S. Renewable Fuel Standard (RFS) requires the blending of increasing quantities of biofuels into the U.S. surface vehicle transportation fuel supply. Developed initially in 2005 and expanded in the Energy Independence and Security Act (EISA) of 2007, the goals of the RFS program are to reduce both greenhouse gas emissions and US dependence on oil imports. The RFS requirements are met through a system of tradable compliance permits called RINs ("Renewable Identification Numbers").

RINs are generated when a renewable fuel is produced or imported and are detached when the renewable fuel is blended with petroleum fuel for retail sale, at which point RINs can be traded. Refiners and refined-petroleum product importers ("obligated parties") must hand in ("retire") RINs annually to the U.S. Environmental Protection Agency (EPA) in proportion to the number of gallons of non-renewable fuels they sell into the surface transportation fuel pool. The sale of a RIN by a biofuel producer to an obligated party serves as a tax on petroleum fuels and a corrective subsidy to renewable fuels, and is revenue-neutral across the fuel market as a whole.

This paper examines the extent to which RIN prices are passed through to wholesale and retail fuel prices. This question is of interest for several reasons. First, if RIN prices are less than fully passed through to wholesale fuel prices, then an obligated party with a net RIN obligation is left with net RIN price exposure, so that an increase in RIN prices creates a financial burden on the obligated party that is not recouped by higher refined product prices. Second, the goal of the RFS is to increase the consumption of renewable fuels, and in theory the market mechanism whereby that happens is by RIN prices passing through to reduced pump prices for fuels with high renewable content and to increased pump prices for fuels with low renewable content. Thus a central question for the RFS is whether this pass-through of RIN prices occurs at the retail level. Third, a more general question on which there is a large literature concerns the pass-through of costs to wholesale and retail fuel prices. The costs studied here, RIN prices, fluctuate substantially on a daily basis, providing an opportunity to estimate dynamic pass-through relations at the daily level.

Through 2012, RIN prices were low, and the RIN market received little public attention. Starting in the winter of 2013, however, RIN prices rose sharply in response to an enhanced understanding that the RFS volumetric standards were approaching the capacity of the fuel supply to absorb additional ethanol through the predominant blend, E10, which is up to 10% ethanol, referred to in the industry as the "E10 blend wall." Throughout 2013-2015, RIN prices fluctuated through a wide range. These fluctuations have been widely and convincingly attributed by market observers and academics as stemming from the E10 blend wall combined with policy developments concerning the direction of the RFS (Irwin (2013a,b, 2014), Lade, Lin, and Smith (2014)). As a result, these RIN price fluctuations serve as an exogenous source of variation that allows us to identify RIN price pass-through.

The question of RIN price pass-through to retail fuels has been addressed recently by the EPA in the context of its proposed rule for the 2014, 2015, and 2016 standards under the RFS (Burkholder (2015)). That work examines the link between RIN prices and refined fuels by examining the relationship between price spreads on physically comparable fuels with different RIN obligations to the value of the net RIN obligation of that spread. For example, diesel fuel and jet fuel have similar chemical compositions, but diesel fuel is obligated under the RFS whereas jet fuel is not. Thus the spread between the spot prices of diesel and jet fuel, both in the U.S. Gulf, provides a comparison that in theory should reflect the price of the RIN obligation of diesel fuel under the RFS while controlling for factors that affect the overall price of oil, local supply disruptions, and evolving features of the petroleum market that might affect the diesel-gasoline spread or the crack spread. In the retail market, Burkholder (2015) also examines the spread between E85, a fuel with between 51% and 83% ethanol, and E10, the dominant fuel during this period, which contains up to 10% ethanol. As is explained in the next section, during this period the net RIN obligation from blending E10 is essentially zero, so Burkholder (2015) also examines the effect of daily RIN price fluctuations on E10 prices.

This paper complements the analysis in Burkholder (2105). Burkholder's (2015) analysis is based on inspection of time series plots. The main contribution of this paper is to use econometric methods to estimate the extent of pass-through, to estimate pass-through dynamics, and to quantify the sampling uncertainty of these estimates. Like Burkholder (2015), we examine the link between fuel price spreads and the value of net RIN obligation of those fuels. We also use a longer data set and examine some wholesale spreads between obligated and non-obligated fuels not examined in Burkholder (2015).[1]

[1] For diesel, these spreads are the spread between U.S. diesel and jet fuel (both in the Gulf; diesel is obligated but jet fuel is not) and U.S. diesel and diesel sold into the European market (and thus not subject to the RFS), specifically

The empirical analysis in this paper examines both the long-run pass-through coefficient and the short-run pass-through dynamics. We examine the long-run pass-through using levels regressions. Because many of these prices fluctuate seasonally, our base specifications control for seasonality. Even in thick wholesale markets, this pass-through might not be immediate for various reasons including information lags. We therefore examine the dynamic pass-through of RIN prices using both structural vector autoregressions and distributed lag regressions.

This paper also relates to the substantial literature estimating the pass-through of changes in crude oil prices to retail prices, as well as whether this pass-through depends on the direction of the change in crude prices; see, for example, Borenstein et al. (1997), Bachmeier and Griffin (2003), and Lewis (2011). Relative to this literature, the contribution of this paper is to examine pass-through for this specific cost which is central to the design and operation of the RFS, and to provide additional evidence on price pass-through dynamics at the daily level.

Section 2 provides additional background on RINs, the RFS program, and RIN obligations. Section 3 describes the data. The regression methods and results are presented in Section 4, and Section 5 concludes.

2. RINs and the RFS Program

The RFS program divides renewable fuels into four nested categories: total renewable, advanced, biomass-based diesel (BBD), and cellulosic. Under the EISA, each of these four categories has its own volumetric requirements, which the EPA translates into four corresponding fractional requirements through annual rulemakings. As is shown in Figure 1, these categories are defined by the reduction in life-cycle emissions of greenhouse gasses (GHGs), relative to petroleum, by feedstock, and by fuel characteristics.

Production of renewable fuels generates RINs, and there are four types of RINs corresponding to the different categories of fuel under the RFS: cellulosic fuels generate D3 RINs, BBD generates D4 RINs, advanced non-cellulosic non-BBD fuels generate D5 RINs, and conventional fuels (renewable fuels that meet the 80% lifecycle GHG emissions reduction

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the New York Harbor diesel – Rotterdam diesel spread and the U.S. Gulf diesel – Rotterdam diesel spread. For gasoline, these spreads are the New York Harbor RBOB (reformulated blendstock for oxygenate blending) – Euro-BOB spread (RBOB is obligated, Euro-BOB is not), and the spread between New York Harbor RBOB – Brent oil and Los Angeles RBOB – Brent oil.

requirement, but do not qualify as advanced biofuels) generate D6 RINs. During the period of the data, most of the renewable fuels produced were conventional (primarily corn ethanol), followed by biomass-based diesel and advanced biofuels. As a fraction of the overall market, a negligible amount of cellulosic biofuels were produced during this period so D3 RINs are ignored for the empirical analysis here.

The annual RFS regulations specify that for each gallon of petroleum fuel (diesel or gasoline) blended into the fuel supply, a minimum fraction of a gallon of each category of renewable fuels must also be blended. Compliance with this mandate is demonstrated by turning in RINs with the EPA. The compliance system is nested, so a D4 RIN can be used to demonstrate compliance with the BBD mandate, the Total Advanced mandate, or the Total Renewable mandate. Similarly, a D5 RIN can be used to demonstrate compliance with the Total Advanced or Total Renewable mandate. A D6 RIN can only be used to demonstrate compliance with the Total Renewable mandate. During 2013, there were 13,351 million D6 RINs generated, almost entirely from corn ethanol, there were 558 million D5 RINs generated, slightly over 80% of which were produced by advanced non-cellulosic ethanol (mainly Brazilian cane ethanol), there were 2,739 million D4 RINs, corresponding to 1,765 million wet gallons of biomass-based diesel, and there were 0.4 million D3 RINs generated.

Figure 2 shows RIN prices for the period of our data, January 1, 2013 – March 10, 2015. For the purpose of the empirical research in this paper, this was a period of high RIN price volatility, primarily in 2013 but also, to a lesser extent, in 2014-15. In the winter of 2013, D6 RIN prices rose from under \$0.10 to much higher prices, hitting at \$1.40 in the summer of 2013 before falling back to under \$0.30 in the late fall of 2013. Prices were more stable during 2014, although they rose in the winter of 2014-15. As discussed in Burkholder (2015), the initial rise in RIN prices in the winter of 2013 stemmed from increasing market awareness that the RFS standards were approaching or exceeding the so-called E10 blend wall, the amount of ethanol that can be blended into E10, the dominant blend of gasoline which is up to 10% ethanol. As is suggested by the event markers in Figure 2 and as is discussed in detail by Irwin (2013a,b, 2014) and Lade, Lin, and Smith (2014), the subsequent variations in RIN prices arose in large part because of changing expectations about future RFS policy, including a leaked proposal for 2014 volumes, a 2014 proposal which was never finalized, and EPA public statements indicating evolving policy, and repeated delays of proposed standards for 2015. More generally, the movements in RIN prices over this period were not linked to economic growth, shifts in diesel vs. gasoline demand, or other features that might affect price spreads between obligated and non-obligated fuels other than through RIN prices themselves.

Two additional features of the RIN prices in Figure 2 bear comment. First, because of the nested structure, the RIN prices satisfy the inequalities, $P_{D4} \geq P_{D5} \geq P_{D6}$. Second, during most of this period, the three RIN prices tracked each other closely. The reason for this is that during most of this period, biodiesel was being produced in excess of its volumetric requirement and D4 RINs were being used to satisfy the total advanced and total renewable requirements.

***Fractional RIN obligation*.** During the time period of our data, the only fractional standards that were subject to a final rulemaking were the 2013 standards. For each gallon of petroleum gasoline or diesel sold into the surface fuels market, the 2013 standards required retiring with EPA 0.0113 D4 RINs to meet the BBD standard, 0.0162 D4 or D5 RINs to meet the Total Advanced standard, and 0.0974 D4, D5, or D6 RINs to meet the Total Renewable standard; because of the RFS nesting structure, a D4 RIN retired to meet the BBD standard also counts towards the Total Advanced and Total Renewable standard. Assuming the Total Advanced residual requirement is met by turning in 0.0049 (= 0.0162 - 0.0113) D5 RINs and the Total Renewable residual (i.e. conventional) requirement is met by turning in 0.0812 (= 0.0974 - 0.0162) RINs, the value of the 2013 RIN obligation to an obligated party, per gallon of petroleum fuel sold into the transportation market, is:

$$P_{RIN\ bundle} = .0113P_{D4} + .0049P_{D5} + .0812P_{D6}, \qquad (1)$$

where P_{D4}, P_{D5}, and P_{D6} are the price of a D4, D5, and D6 RIN, respectively.[2] Because each of the wholesale spreads is the price difference between an obligated fuel and an exempt fuel, the value of the per-gallon RIN obligation in (1) is the predicted per-gallon RIN price effect on each of the wholesale spreads.

The predicted RIN price obligation on retail fuels depends on the fractions of gallons of petroleum and renewable fuel blended into a gallon of retail fuel. Specifically, we also examine

[2] Because of the nested structure, the Total Advanced residual (Total Advanced minus BBD standards) can be met with either a D5 RIN or a D4 RIN generated by BBD production in excess of the BBD standard. Because of market arbitrage, however, even if the Total Advanced residual is met by an excess D4 RIN, then the D4 and D5 RIN prices will be the same, so (1) still provides the value of the RIN bundle.

the pass-through of RIN prices to retail (pump) prices of E10 and E85 (which can be between 51% and 83% ethanol). Blending one gallon of E10 generates 0.1 D6 RINs, but obligates 0.9 gallons of RIN obligations. The Energy Information Administration has estimated that, on average, E85 is 74% ethanol, so blending 1 gallon of E85 generates 0.74 D6 RINs and entails 0.26 gallons of RIN obligations. Thus, for these two retail fuels, the value of the net RIN obligations are:[3]

$$\textit{Net E10 RIN obligation price} = -0.1P_{D6} + 0.9\times P_{RIN\ bundle} \tag{2}$$

$$\textit{Net E85 RIN obligation price} = -0.74P_{D6} + 0.26\times P_{RIN\ bundle} \tag{3}$$

For example, if the prices of D4, D5, and D6 RINs are all one dollar, then the price of the RIN bundle is 0.097, the net E10 RIN obligation is -0.012, and the net E85 RIN obligation is -0.715. For RIN prices observed since 2013, the basic pattern is that the net E10 RIN obligation is near zero and negative, while the net E85 RIN obligation is large and negative. Diesel, which is not considered in this study, has a small positive net RIN obligation over this period.

The price of the net RIN obligation for the E85-E10 spread is the difference in the net RIN obligation prices of the respective fuels:

$$P^{net}_{RIN,E85-E10,t} = \textit{Net E85 RIN obligation price} - \textit{Net E10 RIN obligation price}. \tag{4}$$

3. The Data and Descriptive Statistics

The data consist of daily fuel and D4, D5, and D6 RIN prices from January 1, 2013 to March 10, 2015. Prices on D4, D5, and D6 RINs are from Progressive Fuels Limited (PFL).[4]

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[3] Equations (2) and (3) make two approximations: (a) all the ethanol blended into E10 and E85 is conventional (corn) ethanol, however in reality some of this ethanol is cane ethanol that generates a D5 RIN; (b) all biodiesel generates D4 RINs, however in reality some biodiesel generates D5, D6, and D7 RINs. However the omitted volumes are small so these approximations have negligible effect on the predicted net RIN obligation prices.

[4] RIN price data from PFL are proprietary. PFL can be reached online at www.progressivefuelslimited.com and by phone at 239-390-2885. Our PFL data end November 30, 2014, and were filled in using OPIS data. The OPIS data has some missing values (most notably D5 prices for January 2015), which were filled in using Bloomberg. Some missing values remained, all for D5 RINs in January 2015, and those missing values were filled in using data from the most recent nonmissing trading day. These RIN prices are traded prices and do not necessarily reflect prices embedded long-term contracts for RINs.

Domestic wholesale prices were obtained from the Energy Information Administration:[5] NYMEX prompt-month futures prices for reformulated blendstock for oxygenated blending (RBOB)-New York Harbor, and spot prices for Brent oil, RBOB-Los Angeles, Ultra-low sulfur No. 2 diesel-New York Harbor and U.S. Gulf Coast, and Kerosene-type jet fuel-U.S. Gulf Coast. Two wholesale European prices, reported by Argus, were used: the Rotterdam barge German diesel (10ppm sulfur) price, and the price of European blendstock for oxygenated blending (EBOB), FOB Rotterdam (both quoted in dollars per tonne, converted to dollars per gallon). Retail fuels prices for diesel, E10, and E85 are national average pump prices produced by the American Automobile Association and reported by (and downloaded from) Bloomberg.[6]

Weekends and U.S. holidays were dropped, so the resulting data are for U.S. business days. In some cases we aggregate the data to weekly, by which we mean five consecutive business days.

From these data, we constructed six wholesale spreads and one retail spread (E85-E10) which, along with changes in E10 prices, are the focus of the analysis. Recall that obligated fuels are those sold for use in the surface transportation sector in the United States; non-obligated fuels are fuels used in Europe and fuels used domestically for purposes other than surface transportation, such as jet fuel. The wholesale prices are the price differences, in dollars per gallon, between a fuel that is obligated under the RFS and a similar fuel that is not obligated:

Diesel spreads

Gulf diesel-jet fuel spread = Ultra-low sulfur No. 2 diesel spot, U.S. Gulf – Jet fuel, U.S. Gulf

NY-Rotterdam diesel spread = Ultra-low sulfur No. 2 diesel spot, New York Harbor – Barge diesel, Rotterdam

Gulf-Rotterdam diesel spread = Ultra-low sulfur No. 2 diesel spot, U.S. Gulf – Barge diesel, Rotterdam

[5] Spot prices were downloaded from http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm, and futures prices were downloaded from http://www.eia.gov/dnav/pet/pet_pri_fut_s1_d.htm.

[6] The only adjustment for outliers was for the E85 price, which has five episodes of large measured price changes that are reversed within one to four days and appear to be measurement errors; these observations were omitted from the regressions.

BOB spreads (wholesale)

NY RBOB -EBOB spread = RBOB prompt -month futures, New York – EBOB, Rotterdam

NY RBOB-Brent spread = RBOB prompt-month futures, New York – Brent spot

LA RBOB-Brent spread = RBOB spot, Los Angeles – Brent spot

In addition, we consider the retail fuel E85-E10 spread (= E85 price – E10 price).[7]

***Summary statistics*.** Table 1 provides the mean and standard deviation of the seven spreads, the E10 price, and the net RIN obligations. The standard deviations of the wholesale refined product spreads over this period are less than $0.10. The RBOB -Brent spreads have a larger standard deviation, reflecting in part seasonal movements in RBOB. The value of the net RIN bundle for these wholesale fuels averaged $0.056 over this period, with a standard deviation which is one-half to one-fourth that of the refined product spreads. The largest fluctuations are in the E10 price, which moved significantly over this period both for seasonal reasons and because of the sharp drop in oil prices starting in July 2014. The net RIN obligation on the E85 -E10 spread is large and negative, averaging $0.393/gallon over this period. Notably, the standard deviation of the E85-E10 net RIN obligation exceeds the standard deviation of the E85 -E10 spread by one-fourth; this large variation in the E85-E10 net RIN obligation this sample provides an opportunity for precise estimation of RIN pass -through to E85. The fact that the standard deviation of the E85 -E10 net RIN obligation exceeds that of the spread is suggestive of incomplete pass -through, however in principle this inequality also could arise with complete long-run pass-through where the retail spread smooths out high frequency fluctuations in the net RIN obligation, a possibility examined in the regression analysis in the next section.

***Time series plots*.** Figures 3-5 plot, respectively, the time series data on the wholesale diesel spreads, the RBOB spreads, and the E85-E10 spread along with the value of the RIN obligation per gallon of petroleum, all in dollars per gallon. First consider the wholesale spreads. There are several common features of the data that are evident across the time series. First, many of the spreads show seasonal patterns. This is particularly the case for the BOB -Brent spreads:

[7] Another spread of interest is the pump diesel -E10 spread. Pump diesel has a lower renewable content than E10 so entails a net RIN obligation, however this RIN obligation is small, with small variation over the sample compared to variation in the pump diesel -E10 spread, making econometric analysis of the pump diesel -E10 spread challenging. We therefore leave analysis of the pump diesel-E10 spread

from 2006-2015, seasonals explains half the variance in the daily NY RBOB -Brent spread and have a range of $0.30. There are also seasonal patterns in the diesel spreads, although they are smaller, for example the range of seasonal fluctuations in the Gulf diesel – Gulf jet fuel spread is approximately $0.05.[8] Second, several of the series have substantial high-frequency noise in the form of quickly reverting prices. This is particularly true for the NY-Rotterdam and Gulf-Rotterdam diesel spreads, but also for the NY RBOB – EBOB spread and the E85-E10 spread. Third, while the range of variation of the diesel spreads is roughly the same as the RIN price obligation, the BOB and retail spreads vary over much larger ranges than the RIN price obligation, consistent with the standard deviations in Table 1.

Consistent with the analysis in Burkholder (2015), the wholesale spreads in Figures 3 and 4 broadly move with the RIN obligation price; however, variation in the RIN obligation price is just one of many reasons for movements in these spreads. Some of these non-RIN movements are idiosyncratic to certain spreads, for example the spikes in the NY-Rotterdam diesel spread during the late winters of 2014 and 2015, indicating temporarily tight markets for diesel and heating oil in the Northeast U.S. Other non-RIN movements are more persistent, such as the decline in the NY RBOB-EBOB spread during the summer of 2014 at a time that the value of the RIN obligation was slowly increasing.

Figure 5 presents mixed evidence on the comovements of the E85-E10 spread and its net RIN obligation price. E85 prices fell, relative to E10, during the spring and summer of 2013 as RIN prices initially rose (and the net E85-E10 RIN obligation price fell, because E85 is a renewables-heavy fuel), however E85 prices rose only slightly as RIN prices fell in the fall of 2013, and through 2014 and 2015 fluctuations in the RIN obligation price appear less connected to the spread.

Scatterplots. The plots in Figures 3-5 show broad trends but do not illustrate the link between timing in changes in RIN prices and the fuel spread. Figures 6-8 therefore provide an initial look at the link between changes in the value of the RIN bundle and the change in the spread. For these scatterplots, the data are aggregated to weekly averages and the changes are weekly changes of weekly averages (the weeks are the five business days ending on Tuesday to minimize missing weeks due to holidays).

[8] These seasonal statistics are computed by regressing the spread on the seasonal variables discussed in Section 4, using data from October 2005-March 2015 for the NY RBOB-Brent spread and from June 2006-March 2015 for the Gulf diesel-jet fuel spread, the full period for which EIA provides these data.

For the wholesale fuels (Figures 6 and 7), the scatterplots show the weekly change in the spread vs. the weekly change in the RIN price obligation in the same week. The scatterplots generally show a positive association between changes in RIN prices and changes in the wholesale spreads between obligated and non-obligated fuels. However, consistent with the spreads changing for many reasons other than RIN prices, the scatters are dispersed.

Because of delays in pricing in retail fuels markets, the scatterplots for the retail fuels in Figure 8 show the weekly change in the E85-E10 spread (upper) and the change in the E10 price (lower) against the prior-week change in the net RIN obligation price. In contrast to the wholesale fuel scatterplot, the E85-E10 scatterplot shows very little evidence of pass-through, at least at this relatively short time lag. Because E10 has a net RIN obligation of approximately zero under the 2013 RFS standards, theory suggests that there would be little relationship between changes in RIN prices and changes in E10 prices, and the E10 scatterplots in Figure 8 are consistent with this theoretical prediction of no relationship, whether the data are seasonally adjusted or not.[9] These scatterplots, however, are not able to capture fully the dynamics of the RIN price-spread relationship; doing so requires turning to time series regressions.

4. Time Series Analysis: Methods and Empirical Results

We now turn to time series regression analysis of the relation between changes in the spreads and changes in the price of the net RIN obligation. The first set of specifications estimate levels relations with no lags which, as is discussed further below, have the interpretation of estimating the long-run pass-through coefficient. The second set of specifications uses vector autoregressions to estimate pass-through dynamics. In the vector autoregressions, the dynamic effect of a RIN price shock is identified by assuming that the shock to the RIN bundle is exogenous at the daily level. Finally, as a specification check we present a third set of results in which the dynamic pass-through is estimated using distributed lag regressions. In all cases, we initially present results for each spread individually. Generally speaking, we find that the pass-through coefficients and their dynamics are similar across wholesale spreads, but are estimated imprecisely. Because the pass-through theory does not differentiate among wholesale spreads,

[9] For the purpose of Figure 8, the seasonally adjusted E10 series was by regression-based seasonal adjustment as described in Section 4, with the seasonal coefficients estimated over the period October 2006 to January 2012.

and because the markets are connected and have overlapping participants, we therefore estimate pooled specifications for the wholesale spreads in which the pass-through coefficients are constrained to be the same across spreads.

Because of the seasonal movements in many of the prices, and because the 2013 RIN price increase in the spring and decline in the fall coincides with some seasonal fuel patterns, in all specifications the leading cases include seasonal adjustment. A typical method for seasonally adjusting monthly data is to include 11 monthly indicator variables, however with these daily data, monthly indicators would induce jumps between months. Instead, we use sines and cosines evaluated on calendar days at the first four seasonal harmonic frequencies.[10]

Levels specifications. We begin by investigating the long-run pass-through relation between the level of the net RIN obligation price and the spreads, which is the focus of the discussion in Burkholder (2015).

Visual inspection of Figures 2-5 indicates that, for the relatively short data span at hand, there are long swings (low-frequency movement, or persistence) in both the spreads and RIN prices. It is natural to expect the spreads to be revert to a mean value over a sufficiently long period, that is, for the spreads to be stationary. Over the short sample at hand, however, the assumption of stationarity might not be a good statistical description of these series. A large body of econometric methods and practice has developed around handling time series data with low-frequency movements. The benchmark approach is to ascertain whether the series at hand are integrated of order zero or one and, if they are integrated of order one, whether they are cointegrated, that is, have common long-term movements. If the series are stationary but have long-term comovements, as is evident in the time series plots, or if the series are cointegrated, then regressions of the level of the spread on the level of the net RIN obligation price produce estimates of the long-term coefficient linking the two series, which in this case is the long-term pass-through coefficient.

Table 2 summarizes the levels regression results for the individual series. First consider the unit root and cointegration tests reported in the lower panel of the table. The RIN prices

[10] Including the first six seasonal harmonics would be equivalent, with monthly data, to including twelve monthly indicators. Preliminary investigation indicated that the full six harmonics were not necessary so for parsimony the first four harmonics were used, and the results are robust to this choice.

appear to be well-approximated as having a unit root over the full sample.[11] As can be seen in Table 2, there is more evidence against the unit root model for the spreads, with all but 3 of the 12 unit root tests for wholesale spreads rejecting the unit root null at the 10% level. The notion that the RIN obligation price and the spread have different orders of integration is internally inconsistent and makes these results difficult to interpret. This said, five of the six cointegration tests reject non-cointegration, which suggests that if the unit root model is adopted then the assumption of cointegration is appropriate. With the preponderance of tests rejecting the unit root model, we focus on levels regressions estimated by OLS. Under the assumption that RIN prices are exogenous, inference on the OLS estimator is valid even if the series are cointegrated, however in that case the OLS estimator will be an inefficient estimator of the long-run relation. As a check, we therefore also report levels regressions estimated using the dynamic OLS (DOLS) efficient cointegration estimator.

We now turn to the levels regression results for the six wholesale spreads. In all specifications, the units of the spread and the RIN price obligation align, so that a coefficient of 1 corresponds to perfect pass-through. Five features of the wholesale spread regression results in Table 2 are noteworthy.

First, for the base specification in row (1) (OLS in levels with the seasonal controls), the estimated coefficients range from 0.68 to 1.57. There is, however, a wide range of precision of the estimates, ranging from a tight standard error of 0.14 for the Gulf diesel-Rotterdam diesel spread to 0.70 for the L.A. RBOB-Brent spread. This precision is consistent with the large non-RIN variation in several of these series evident in Figures 3 and 4.

Second, there are only small differences between the DOLS and OLS estimators. This finding is consistent with the price of the RIN obligation being exogenous and indicates robustness of the long-run pass-through coefficient to whether the series are modeled as cointegrated.

Third, for most of the series the estimated pass-through coefficient is sensitive to whether seasonals are included (compare regressions (4) and (1)). Because the seasonal coefficients are strongly statistically significant for all the spreads and, as discussed above, ignoring seasonals

[11] DF-GLS and augmented Dickey-Fuller unit root tests, applied to the D4, D5, and D6 RIN price series with a constant (no drift, AIC lag selection), fail to reject the null hypothesis of a unit root at the 10% level in 5 of the 6 cases, and in the 6th case rejects the unit root at the 10% but not 5% level.

has the potential for confounding movements in RIN prices with normal seasonal movements in the spreads, we will focus on the results that include the seasonal variables.

Fourth, the subsample estimates are far more precise for 2013 than for 2014-15, consistent with 2013 being the period with the greatest fluctuation in RIN prices. Because these regressions span only a year, or just over a year, they do not include seasonal variables so serve here to confirm that most of the variation in the data is arising from the first half of the sample.

Fifth, regression (3) augments the base set of seasonals (the first four harmonics) with two additional harmonics, so that they would be equivalent to monthly indicators in monthy data. Although using the base set of seasonal variables matters substantially for the results, the differences between using the base set and the augmented set of seasonal variables are negligible.

A straightforward interpretation of the theory of pass-through provides no reason to think that the RIN pass-through should differ across the wholesale spreads, each of which compare an obligated fuel to a non-obligated counterpart. Table 3 therefore presents pooled levels regression in which the pass-through coefficient is constrained to be the same across series (all other coefficients, including seasonals, are unconstrained).

The pooled levels regression results in Table 3 present strong evidence in favor of a precisely estimated unit pass-through coefficient. The regressions in Table 3 are for the three specifications in Table 2 that include seasonals. As expected, pooling improves the precision of the estimators, especially for the RBOB spreads. For diesel, the estimated pass-through coefficient is slightly greater than one, while for gasoline it is less than one, but in all cases it is within one standard deviation of one. When the six wholesale spreads are pooled, the long-run pass-through coefficient is estimated to be 1.01 using OLS or DOLS with the base set of seasonal variables, with a standard error of 0.12.

The results for the E85-E10 retail spread, given in the final two columns of Table 2, are quite different than for the wholesale spreads. Three features of the E85-E10 results are noteworthy. First, regardless of the specification, the pass-through coefficient is in all cases small (the negative coefficients for 2014-15 are relatively imprecisely estimated and do not include seasonals so we put little weight on these estimates). Second, because of the large variation in the E85-E10 net RIN obligation price, the pass-through coefficients estimated using the full sample, and using the 2013 subsample, are all precisely estimated. Third, the results are sensitive to whether seasonals are included. Unfortunately, unlike the wholesale spreads historical data on E85 prices are spotty and we are unable to examine historical seasonal fluctuations in the E85-E10 spread. Because the average ethanol content of E85 varies seasonally, and because ethanol is less expensive than petroleum gasoline on a volumetric basis for most of this sample period, one would expect seasonal fluctuations in the E85-E10 spread and indeed the seasonal coefficients in the E85-E10 regressions are strongly statistically significant. These considerations lead us to put greater weight on the regressions including seasonals. Fourth, consistent with the gasoline pass-through literature, one would expect a delay between changes in the net RIN obligation price and when it shows up in retail prices, even with perfect long-run pass-through. The final column in Table 2 therefore presents regressions in which the net RIN obligation price is replaced by its value 20 business days (approximately one month) prior. With this modification, the negative coefficients in specifications (1) and (2) become approximately zero, and the OLS estimate without seasonals becomes 0.26. In short, ignoring seasonals yields a precisely estimated long-run pass-through coefficient of roughly one-fourth; including seasonals, this coefficient is precisely estimated to be zero.

Structural vector autoregressions by fuel spread. We now turn to an examination of the short-run pass-through dynamics between the net RIN obligation price and the spreads. We initially estimate the pass-through dynamics using bivariate structural vector autoregressions (SVARs), then in the next section compare the SVAR results to ones obtained from distributed lag models.

The SVARs estimate the dynamic response of the two included variables, the net RIN obligation price and the spread, to a structural shock to the net RIN obligation price. Motivated by the discussion in Section 2, we identify the net RIN structural shock by assuming that it is uncorrelated at the daily level with any of the other news determining daily innovations in the spread; this corresponds to ordering the net RIN obligation price first in a Cholesky factorization. All SVARs include the base set seasonal variables. The SVARs are specified in differences, for two reasons. First, the bulk of the statistics in Table 2 on unit roots suggests that the variables are most plausibly treated as stationary. Second, this evidence is not clear-cut, and the estimates obtained from a levels specification will be consistent under unit roots with or without cointegration, although in the latter cases the levels VAR estimates will be inefficient.

Table 4 presents the SVAR estimates of the dynamic pass-through effect, specifically, the structural impulse response of the (level of the) spread to a shock to the net RIN obligation price, for the first 15 business days. As in the levels regression, there is considerable variation in precision across the VARs and, not surprisingly, the estimates of the dynamics are less precise than the estimates of the long-run relations. Still, several interesting patterns emerge. All the SVARs indicate that roughly half to two-thirds of the RIN price is passed through to the wholesale spread in the first day, and by the end of the business week the estimated pass-through is approximately 1, albeit quite imprecisely estimated for some of the series. As in the levels regressions, the most precise estimates are for the Gulf diesel-Gulf jet fuel spread and the Gulf diesel-Rotterdam diesel spread.

Because the wholesale fuels markets are deep and many of the participants are the same, and because the theoretical effect of the RIN obligation price is the same for each of the spreads, we also estimated SVARs pooled across the wholesale spreads, in which the SVAR coefficients on the spread and the net RIN obligation price were constrained to be the same for each spread (seasonals were allowed to differ across spreads).[12]

The pooled SVAR results are given in Table 5. The structural impulse response functions for diesel and for gasoline both show a large, but incomplete, impact effect, with a pass-through that rises over time, and the two sets of 3-fuel impulse response functions are within a standard error of each other. The 6-spread pooled results estimate a pass-through of 0.71 in the first day, rising to 0.90 after five business days. Even with pooling, the dynamic effects remain less precisely estimated than the levels long-run estimate, however there is substantial evidence consistent with large, but initially incomplete pass-through, that becomes complete pass-through after roughly one week.

SVAR results for retail fuels are given in Table 6. The first three columns present different SVARs using daily data; the fourth column estimates a SVAR using weekly data (weeks ending in Tuesday, specified in first differences as an additional specification check). As is the case in the levels regressions, the SVAR results for E85-E10 are quite different than for the

[12] Specifically, this was implemented by estimating a VAR with n spreads and the RIN price obligation, for n+1 variables. The constrained n+1 variable SVAR imposed no feedback across spreads, coefficients at a given lag being equal across spreads, and the same structural impact coefficient, where the RIN price obligation ordered first in a Cholesky factorization. This is equivalent to estimating n bivariate SVARs constrained to have the same coefficients on the spread and the RIN obligation across each SVAR, but allowing different seasonals and intercepts for each spread. In the case n=1 this specializes to the bivariate SVARs in Table 4.

wholesale spreads. With or without seasonals, there is little evidence of pass-through within a week, although without seasonals there is evidence of perhaps 20% pass-through after three weeks in both the daily and weekly regressions. In the weekly regression, even after 8 weeks the pass-through is only 0.29, consistent with the more precise estimates of long-run pass-through obtained from the levels regressions in Table 2 without seasonals. If seasonals are included, then the dynamic pass-through of RIN prices to E85 is essentially zero.

Finally, theory predicts that E10 prices should not be affected by RIN prices, and that is what is found in the SVAR in the final column of Table 6.

Distributed lag regressions by fuel spread. An alternative approach to estimating the dynamic effect of a change in the net RIN obligation price is to use distributed lag regressions. As an additional check, these regressions are specified in first differences. The distributed lag regressions are of the form:

$$\Delta Spread_{i,t} = \mu_i + \beta_i(L)\,\Delta P^{net}_{RIN,i,t} + \gamma_i' W_t + u_{it}, \tag{5}$$

where i varies across the spreads, $\beta_i(L)$ is a lag polynomial, W_t are additional control variables in some of the specifications, and $P^{net}_{RIN,i,t}$ is the price of the net RIN obligation bundle for that spread. The cumulative effect on the spread of a change in the net RIN obligation price after k days is the sum of the first k coefficients in the distributed lag polynomial $\beta_i(L)$.

The results for the individual spreads are summarized in Table 7. For comparability to the VAR results, the specifications include seasonal controls and are estimated over the full sample, and include the current value and fifteen lags of the net RIN obligation price so as to estimate the first fifteen cumulative dynamic multipliers. In general, the results for the individual spreads are consistent with those for the counterpart SVAR impulse response functions, although the estimates from the distributed lag regressions, which have more coefficients than the SVARs, have larger standard errors and are less smooth. For the wholesale fuels, the results are consistent with complete pass-through, although the estimates are imprecise. For the E85-E10 spread, the dynamic pass-through over these first three business weeks is precisely estimated to be small, and is statistically indistinguishable from zero. Also consistent with the previous results, there is also no evidence of pass-through from RIN prices to E10 prices.

Results for pooled distributed lag regressions are given in Table 8. The estimates are comparable to those from the SVARs, although (like the individual distributed lag estimates) have larger standard errors and are less smooth.

Appendix Tables A1 and A2 present additional distributed lag specifications, including specifications in weekly differences to reduce the number of parameters and specifications that include changes in Brent prices (current and lagged) as additional control variables. These results are also consistent with the SVAR and daily distributed lag regressions presented in the text and show (a) general evidence of pass-through for the wholesale fuels, (b) that the 2013 data are more informative than the 2014-2015 data, (c) that some of the results, particularly for the gasoline spreads, are sensitive to controlling for seasonality, and in those cases the seasonal coefficients are typically statistically significant (so the seasonal specifications should be used), (d) there is little evidence that E10 prices move with RIN prices, and (e) the pass-through of RIN prices to E85 is small, and once seasonals are accounted for, is roughly zero.

5. Discussion and Conclusions

Taken together, these results support the view that RIN prices are passed through quickly, but not immediately, into the wholesale prices of obligated fuels. Based on the pooled, six-fuel SVAR, 57% of a shock to the price of the RIN obligation is passed through in the same day, rising to 97% after six business days (standard error of 31 percentage points). The pooled long-run pass-through estimate is 1.01 with a standard error of 0.12. This rapid and complete pass-through is consistent with economic theory and with efficiently operating wholesale fuels markets.

The results for E10 are also consistent with economic theory: the net RIN obligation of E10 is negligible, and there is no statistically discernable movement of E10 prices with RIN prices.

In contrast to these results, there appears to be little or no pass-through of RIN prices to E85 retail prices. Because the variation in the E85-E10 net RIN obligation price is very large during this sample, this absence of pass-through is precisely estimated, however whether the estimate is zero or roughly 30% depends on whether the results adjust seasonal fluctuations or not, respectively. The presence of seasonals in E10 prices and in the other fuels, and in the physical composition of E85, suggests that seasonals should be included in the specifications, which leads to a precise estimate of no pass-through.

This analysis is subject to several caveats. Throughout, identification of the pass-through coefficients is predicated on some aspect of exogeneity of RIN price movements, for example the SVAR analysis identifies unexpected changes in RIN prices as arising from features related to the RFS or biofuels markets. We argued that this is plausible given unique features of the biofuels market and the RFS during this data span, in which RIN prices fluctuated due to policy developments, fundamentally, changing perceptions of how the blend wall would be handled within the RFS program. To the extent that RIN prices moved because of broader economic or petroleum market developments that would directly affect the spreads, this identifying assumption would be brought into question.

One implication of these results, discussed in detail in Burkholder (2015), is that an obligated party with a net RIN obligation, such as a merchant refiner, is able to recoup their RIN costs on average through the prices they receive in the wholesale market, although this mechanism would not be apparent on the balance sheet of the obligated party because there is no explicit revenue line item offsetting the explicit cost of purchasing RINs. Even with full pass-through, however, an obligated party could face RIN price risk because of timing differences between when the RIN obligation is incurred and when RINs are acquired.

To us, the most intriguing and challenging finding here is the near absence of pass-through of RIN prices to retail E85 prices. While RIN prices might be passed through at some retail outlets at some times, this is not the case on average using national prices. The goal of the RFS program is to expand the use of low-carbon domestic biofuels, and the key economic mechanism to induce consumers to purchase high-renewables blends is the incentives provided by RIN prices. If the RIN price savings inherent in blends with high biofuels content are not passed on to the consumer, then this key mechanism of the RFS is not functioning properly. Obtaining a better understanding of the disconnect between fluctuations in RIN prices and pump E85 pricing is an important question for understanding how to achieve efficiently the goals of the RFS.

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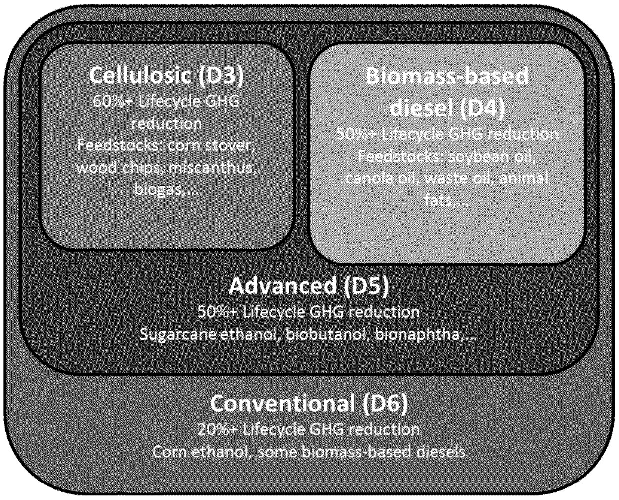

Source: EPA

Figure 1. The RFS Nested Fuel Structure

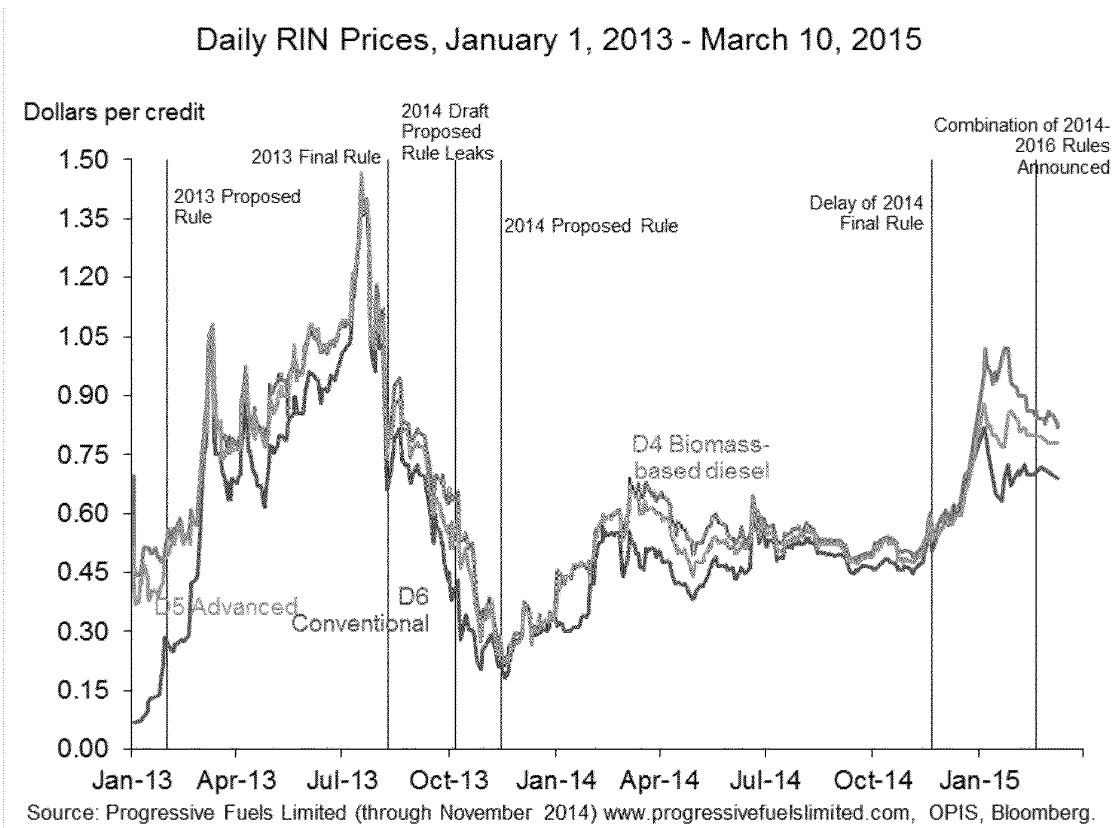

Figure 2.

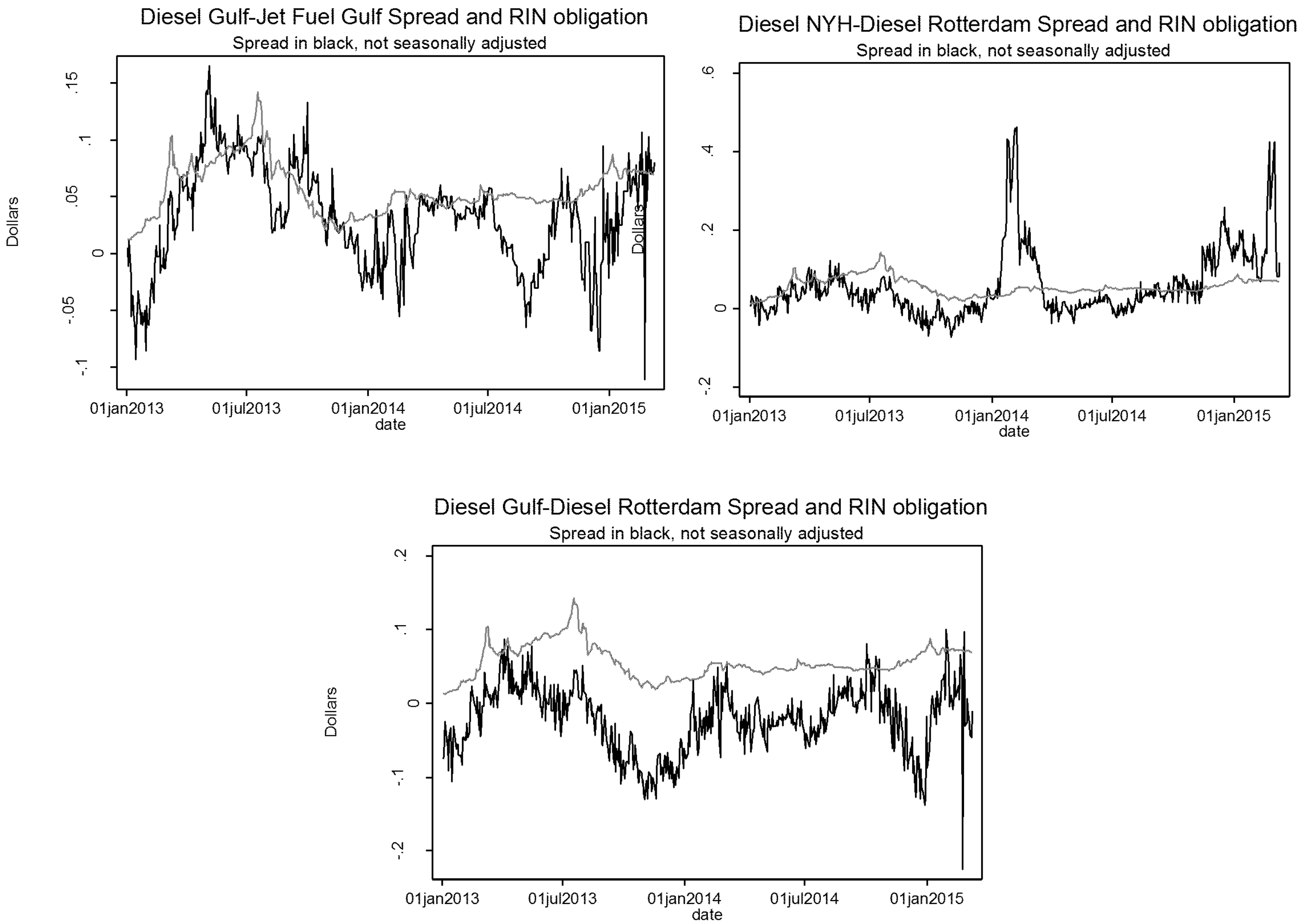

Figure 3. Wholesale diesel fuel spreads and net RIN obligation.

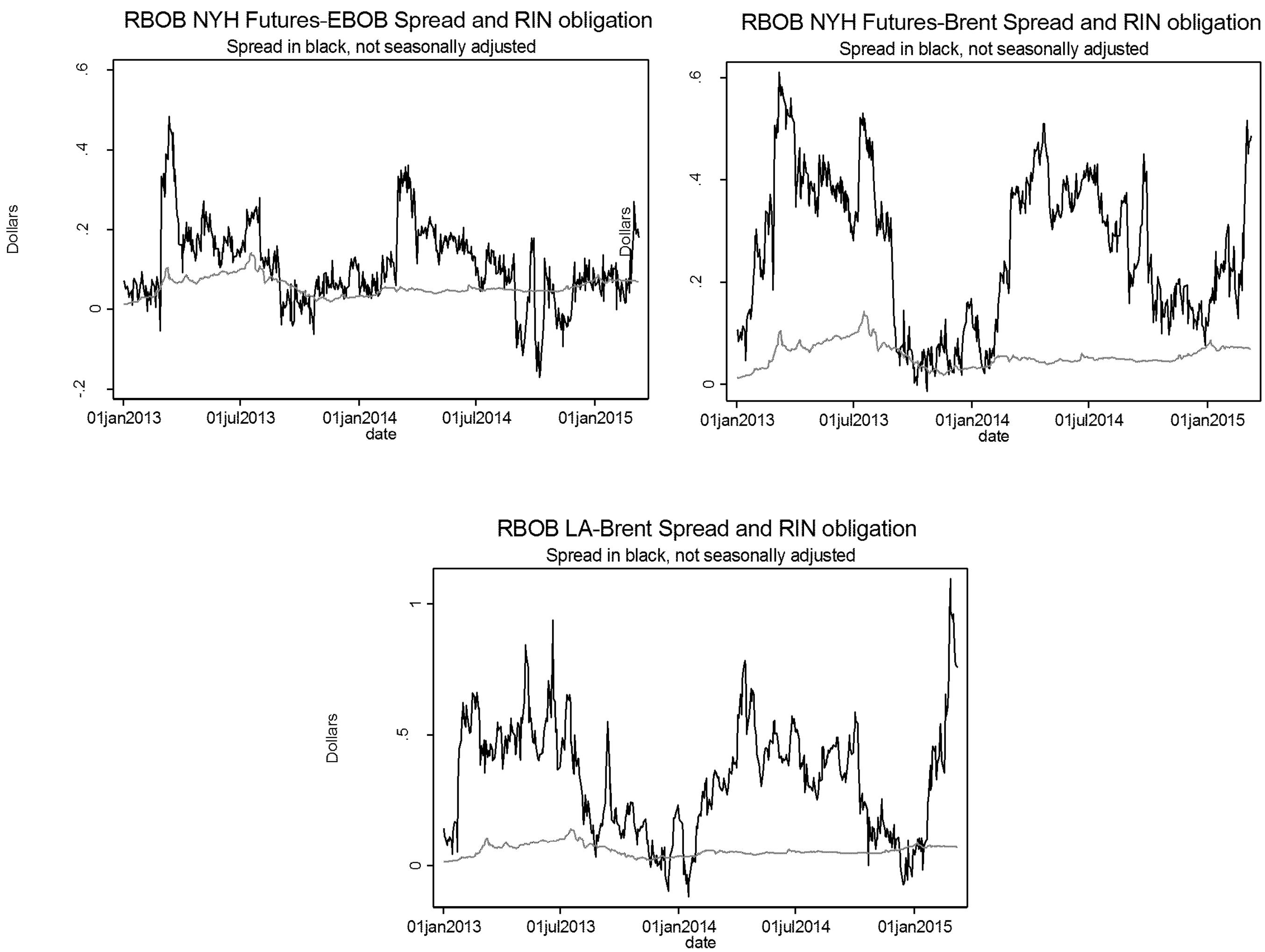

Figure 4. Wholesale gasoline fuel spreads and net RIN obligation.

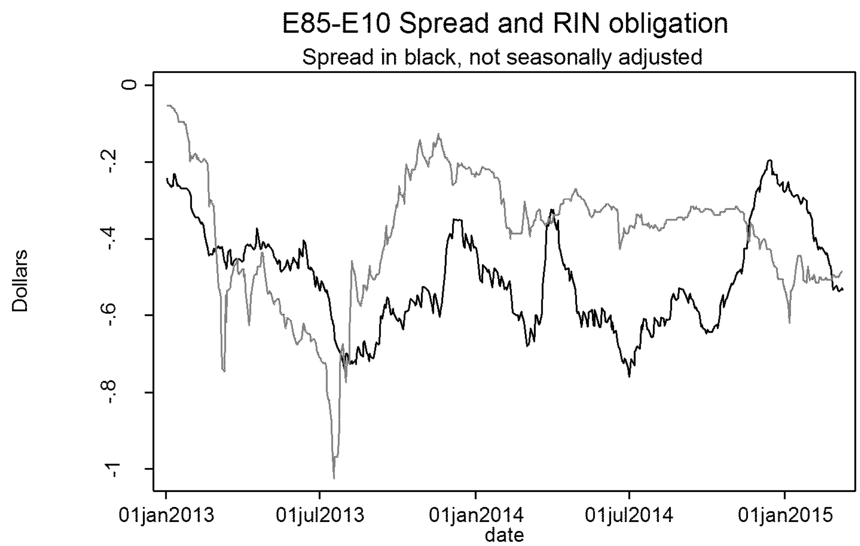

Figure 5. Retail E85-E10 spread and net RIN obligation.

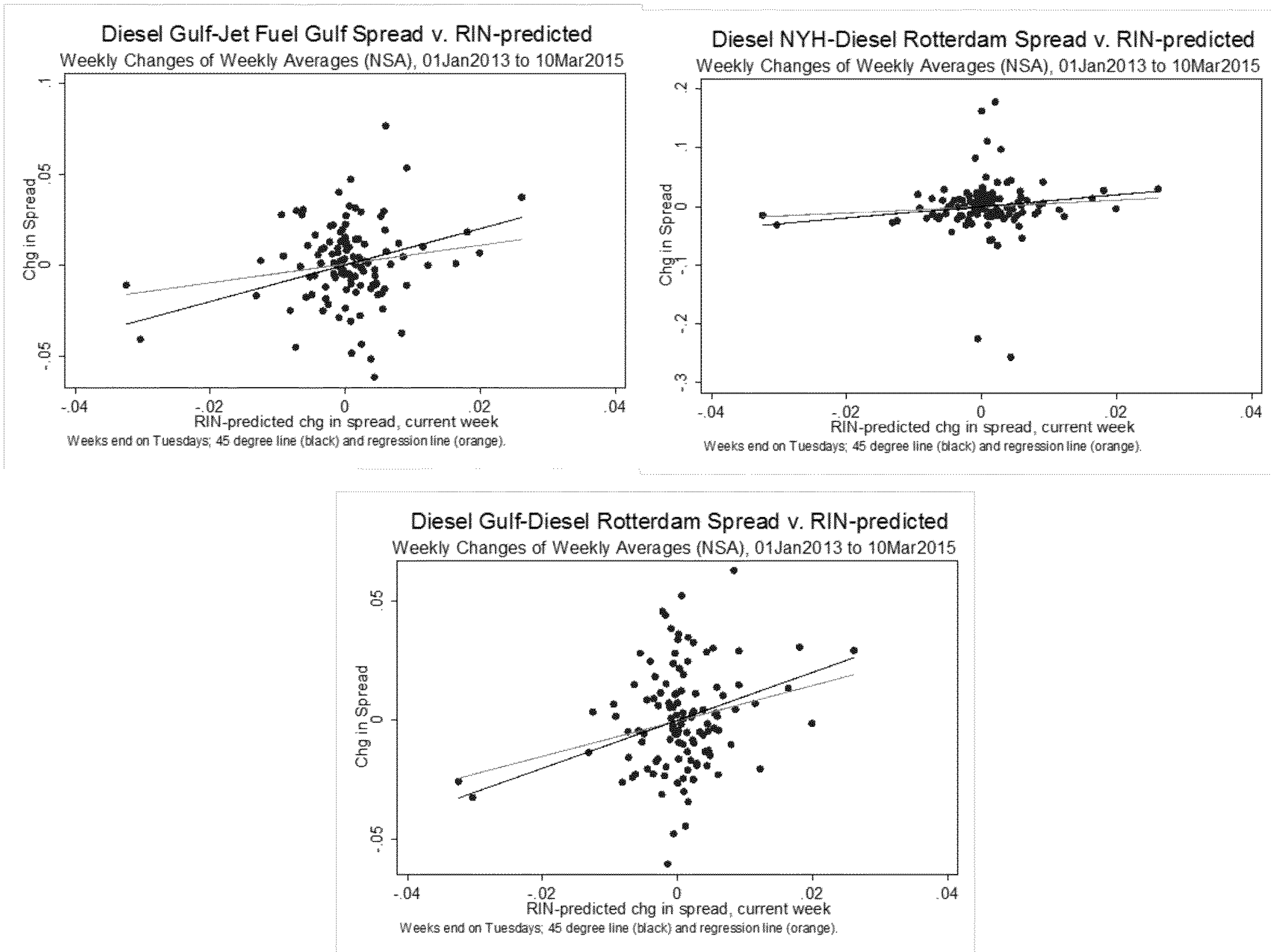

Figure 6. Scatterplots: Wholesale diesel spreads vs. RIN obligation, weekly changes.

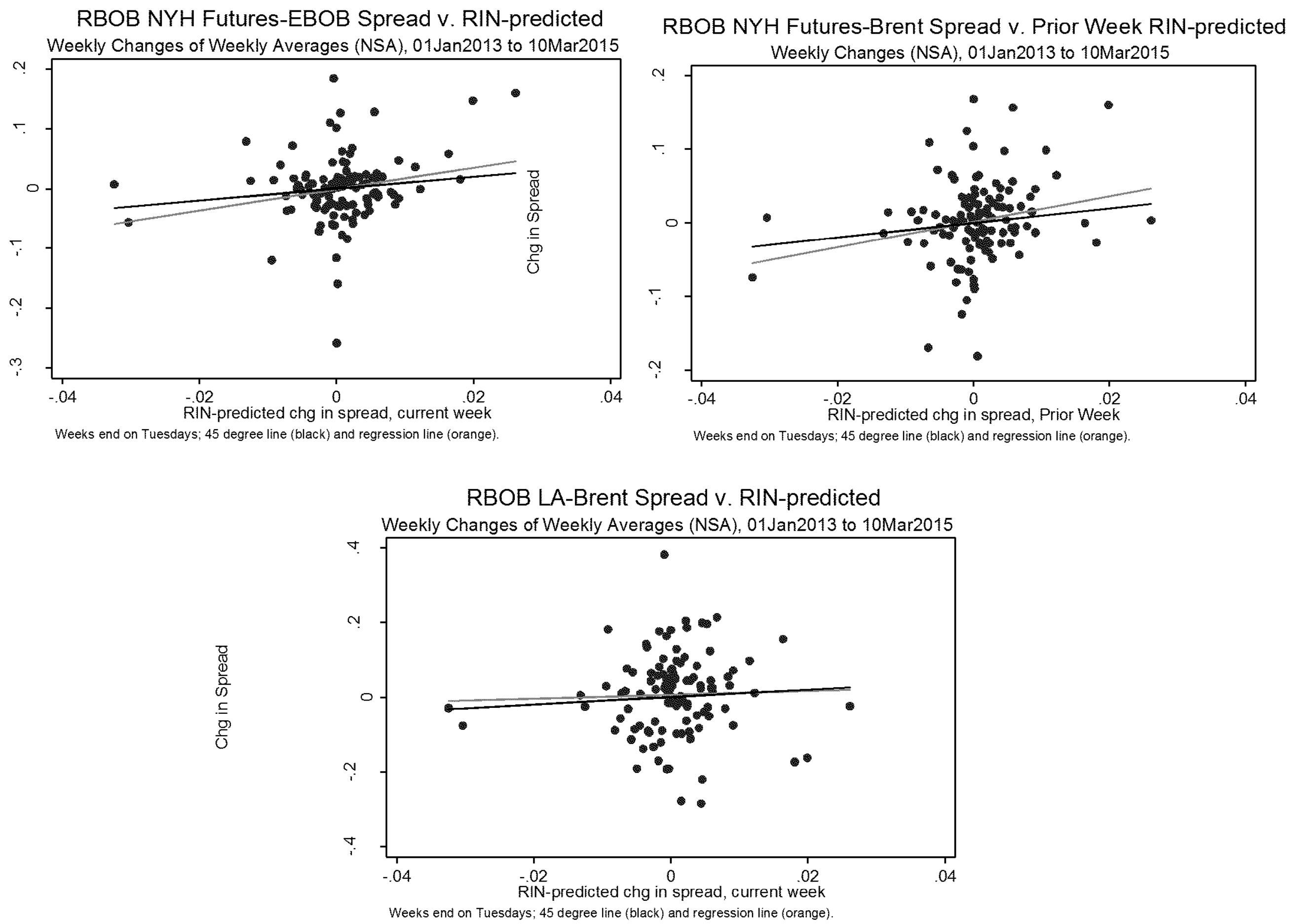

Figure 7. Scatterplots: Wholesale gasoline spreads vs. RIN obligation, weekly changes.

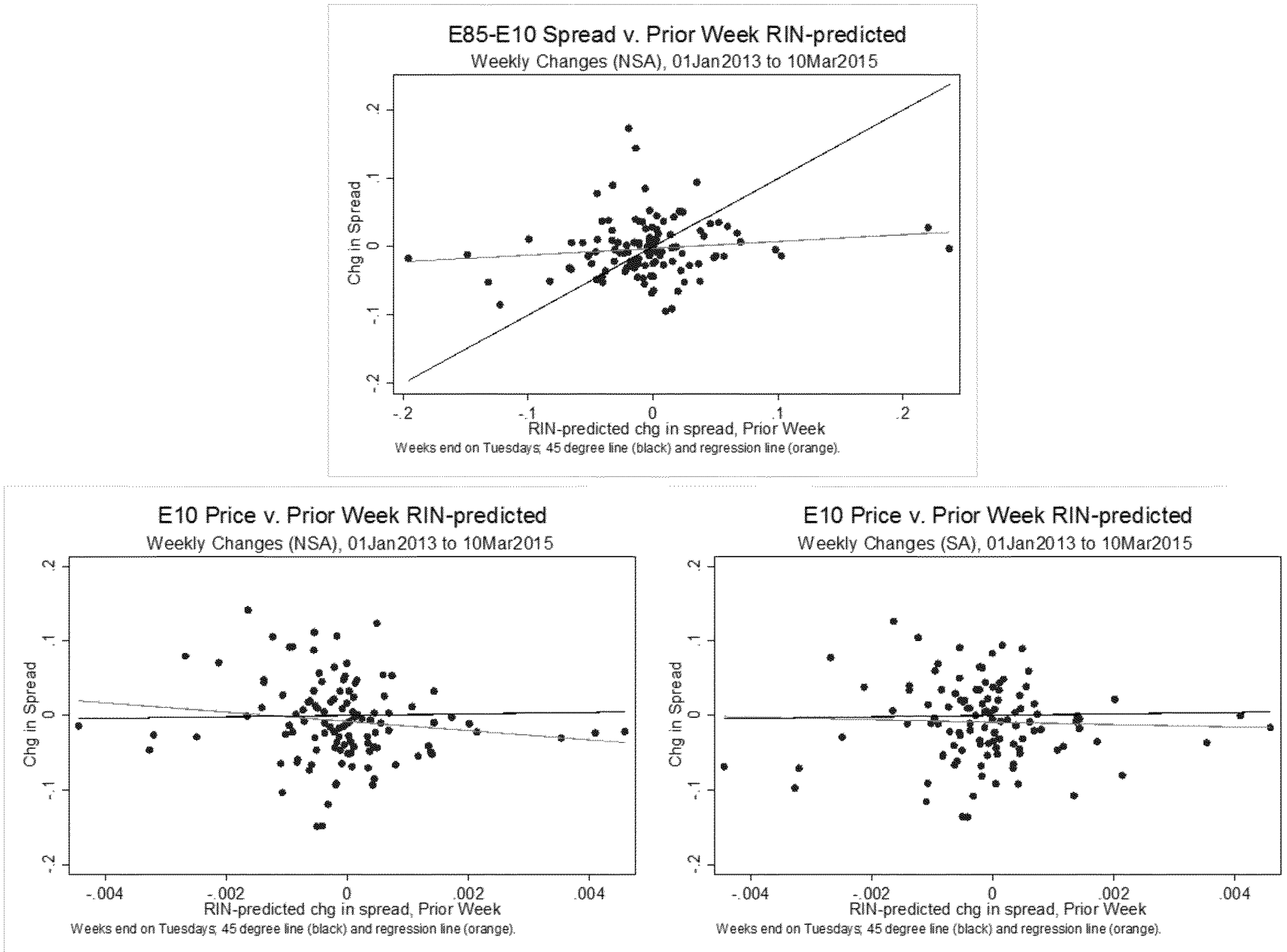

Figure 8. Scatterplots, retail fuels: E85-E10 vs. prior-week RIN obligation (top) and E10 price vs. prior-week net RIN obligation (bottom, NSA and SA), weekly changes.

Table 1. Spreads and prices: summary statistics

	mean	std. dev.	min	max
Fuels and fuel spreads				
Gulf diesel – gulf jet	0.032	0.045	-0.111	0.165
NY diesel – Rotterdam diesel	0.056	0.086	-0.074	0.464
U.S. Gulf diesel – Rotterdam diesel	-0.022	0.046	-0.225	0.100
NY RBOB – Euro BOB	0.109	0.099	-0.171	0.484
NY RBOB - Brent	0.264	0.147	-0.013	0.611
Los Angeles RBOB – Brent	0.331	0.213	-0.123	1.095
E85 – E10	-0.503	0.131	-0.759	-0.195
E10	3.316	0.429	2.037	3.786
Net RIN obligations				
RIN bundle (obligation on wholesale fuels)	0.056	0.023	0.013	0.142
E85-E10 net RIN obligation	-0.393	0.165	-1.026	-0.053

Notes: Units are dollars. Statistics are evaluated over the full sample, Jan. 1, 2013 – March 10, 2015.

Table 2. Fuel spreads levels regressions and unit root/cointegration statistics

	Gulf diesel – Gulf jet	NY diesel – Rott'm diesel	U.S. Gulf diesel – Rott'm diesel	NY RBOB – Euro BOB	NY RBOB - Brent	Los Angeles RBOB - Brent	E85 – E10	E85 – E10 (one-month lag)
Regression coefficients (SEs):								
(1) OLS, full sample, seasonals	1.161***	1.567***	0.818***	0.684**	1.089***	0.720	-0.176*	-0.058
	(0.154)	(0.424)	(0.142)	(0.332)	(0.310)	(0.704)	(0.090)	(0.099)
(2) DOLS, full sample, seasonals	1.214***	1.656***	0.834***	0.573*	1.025***	0.735	-0.196**	-0.066
	(0.155)	(0.459)	(0.159)	(0.307)	(0.327)	(0.730)	(0.091)	(0.107)
(3) OLS, full sample, augmented seasonals	1.152***	1.545***	0.844***	0.620**	1.068***	0.676	-0.194**	-0.050
	(0.152)	(0.411)	(0.135)	(0.266)	(0.304)	(0.613)	(0.089)	(0.097)
(4) OLS, full sample, no seasonals	1.160***	0.771	0.985***	1.812***	3.530***	3.550***	0.095	0.260**
	(0.225)	(0.521)	(0.247)	(0.416)	(0.714)	(1.268)	(0.140)	(0.107)
(5) OLS, 2013, no seasonals	1.153***	0.754***	1.229***	2.045***	4.299***	3.999***	0.243*	0.376***
	(0.271)	(0.153)	(0.248)	(0.377)	(0.647)	(1.238)	(0.127)	(0.078)
(6) OLS, 2014 -15, no seasonals	0.723	3.193*	-0.021	0.073	-0.368	1.415	-0.839**	-0.546**
	(0.567)	(1.634)	(0.687)	(1.122)	(2.684)	(5.881)	(0.344)	(0.254)
Test statistics (no seasonals)								
F on seasonals (*p*-value)	11.38	3.27	6.45	28.35	42.69	29.48	14.40	8.56
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DF-GLS, dependent variable	-1.996**	-2.916***	-1.744*	-3.712***	-1.469	-2.060**	-1.130	-1.130
ADF, dependent variable	-2.441	-3.410**	-2.884**	-4.002***	-2.481	-2.984**	-3.021**	-3.021**
Engle-Granger cointegration	-3.260*	-3.435**	-3.250*	-4.359***	-2.605	-3.349**	-3.162*	-3.140*

Notes: The data are daily and the f ull sample is Jan. 1, 2013 – March 10, 2015. In the OLS regressions, the dependent variable is the spread and the regressor is its net RIN obligation. The coefficient and standard error are on the level of the RIN -predicted spread. DOLS regressions additionally include five leads and five lags of the first difference of the RIN -predicted spread (coefficients not shown). The seasonal controls are sins and cosines evaluated at the first four seasonal frequencies, the augmented seasonals add the fifth and six seasonal frequencies. DOLS and OLS standard errors are Newey -West with 30 lags. The DF-GLS and ADF statistics test the null hypothesis that the dependen t variable (the spread) has a unit root, against the alternative that it is stationary (intercept, no time trend, maximum of 6 lags, lagged determined by AIC); DF-GLS uses asymptotic critical values, ADF uses MacKinnon critical values. The Engle-Granger statistic is (the Engle-Granger augmented ADF) tests the null of no cointegration against the alternative of cointegration, using asymptotic critical values. Tests/coefficients are significant at the *10% **5% ***10% significance level.

Table 3. Pooled levels regressions for wholesale spreads

	Diesel	**Gasoline**	**Diesel and Gasoline**
No. of spreads:	3	3	6
Regression coefficients (SEs):			
(1) OLS, full sample, seasonals	1.182***	0.831***	1.006***
	(0.154)	(0.269)	(0.115)
(2) DOLS, full sample, seasonals	1.235***	0.777***	1.006***
	(0.164)	(0.283)	(0.121)
(3) OLS, full sample, augmented seasonals	1.180***	0.788***	0.984***
	(0.147)	(0.260)	(0.109)

Notes: All regressions are of the form of the spread in levels against its RIN obligation in levels, with additional regressors. The coefficient on the levels is constrained to be the same for the spreads in the column pooled regression but the other coeffic ients are allowed to differ across spreads. Standard errors are Newey -West with 30 lags and allow both for own - and cross-serial correlation in the errors. Coefficients are significant at the *10% **5% ***10% significance level. See the notes to Table 1.

Table 4. Bivariate VARs for wholesale spreads: cumulative structural IRFs, with RIN obligation ordered first

Lag	Gulf diesel – gulf jet		NY diesel – Rott'm diesel		Gulf diesel – Rott'm diesel		NY RBOB - EBOB		NY RBOB - Brent		L.A. RBOB - Brent	
0	0.450	(0.285)	0.637	(0.476)	0.619	(0.385)	0.484	(0.591)	1.272**	(0.540)	0.585	(0.885)
1	0.554*	(0.313)	1.128*	(0.605)	0.808**	(0.403)	0.223	(0.697)	1.588**	(0.681)	0.448	(1.178)
2	0.892***	(0.340)	0.855	(0.697)	0.519	(0.411)	0.554	(0.785)	1.603**	(0.783)	0.901	(1.385)
3	0.611*	(0.357)	1.279*	(0.746)	1.102***	(0.423)	0.855	(0.823)	1.497*	(0.841)	0.740	(1.516)
4	0.825***	(0.284)	1.255*	(0.707)	0.937***	(0.296)	0.939	(0.711)	1.406*	(0.791)	0.744	(1.480)
5	0.903***	(0.261)	1.340**	(0.658)	0.846***	(0.261)	0.974	(0.631)	1.344*	(0.728)	0.680	(1.382)
6	1.004***	(0.232)	1.292**	(0.596)	0.824***	(0.261)	0.953*	(0.521)	1.298**	(0.650)	0.668	(1.244)
7	1.085***	(0.220)	1.304**	(0.575)	0.869***	(0.260)	0.940**	(0.469)	1.259**	(0.612)	0.652	(1.158)
8	1.143***	(0.215)	1.296**	(0.565)	0.832***	(0.249)	0.925**	(0.439)	1.221**	(0.589)	0.641	(1.109)
9	1.186***	(0.215)	1.303**	(0.563)	0.813***	(0.249)	0.913**	(0.427)	1.185**	(0.579)	0.629	(1.084)
10	1.218***	(0.216)	1.301**	(0.564)	0.806***	(0.251)	0.900**	(0.422)	1.150**	(0.576)	0.617	(1.074)
11	1.240***	(0.219)	1.299**	(0.568)	0.798***	(0.253)	0.885**	(0.421)	1.117*	(0.576)	0.604	(1.073)
12	1.254***	(0.221)	1.293**	(0.574)	0.780***	(0.255)	0.869**	(0.421)	1.085*	(0.579)	0.592	(1.076)
13	1.262***	(0.224)	1.286**	(0.580)	0.767***	(0.259)	0.853**	(0.422)	1.055*	(0.583)	0.579	(1.083)
14	1.264***	(0.227)	1.277**	(0.587)	0.755***	(0.262)	0.836**	(0.421)	1.027*	(0.588)	0.567	(1.091)
15	1.262***	(0.229)	1.266**	(0.594)	0.742***	(0.265)	0.819*	(0.419)	1.000*	(0.593)	0.556	(1.098)
Season-als?	Y		Y		Y		Y		Y		Y	
Sample	Full		Full		Full		Full		Full		Full	

Notes: Entries are cumulative structural impulse responses, with asymptotic standard errors in parentheses. Spreads and RIN obligations are specified in levels. The RIN price shock is identified by assuming it equals the RIN obligation price innovation (i.e. the RIN obligation ordered first in Cholesky factorization). Coefficients are significant at the *10% **5% ***1% level.

Table 5. Pooled VARs: Cumulative structural impulse response functions, wholesale spreads

	Diesel		**Gasoline**		**Diesel and Gasoline**	
# spreads	3		3		6	
Lag						
0	0.570**	(0.265)	0.884*	(0.519)	0.711***	(0.259)
1	0.695**	(0.319)	0.887	(0.670)	0.815**	(0.326)
2	0.893**	(0.350)	0.999	(0.783)	1.044***	(0.368)
3	0.885**	(0.377)	0.994	(0.858)	0.948**	(0.400)
4	0.759*	(0.393)	0.786	(0.904)	0.826**	(0.418)
5	0.866**	(0.349)	0.763	(0.850)	0.896**	(0.385)
6	0.968***	(0.314)	0.759	(0.776)	0.992***	(0.351)
7	1.052***	(0.286)	0.791	(0.678)	1.078***	(0.317)
8	1.109***	(0.272)	0.800	(0.617)	1.141***	(0.300)
9	1.163***	(0.264)	0.822	(0.568)	1.193***	(0.292)
10	1.202***	(0.262)	0.833	(0.548)	1.231***	(0.290)
11	1.233***	(0.264)	0.844	(0.542)	1.260***	(0.291)
12	1.254***	(0.267)	0.848	(0.546)	1.279***	(0.293)
13	1.267***	(0.271)	0.848	(0.551)	1.289***	(0.295)
14	1.274***	(0.274)	0.844	(0.554)	1.293***	(0.297)
15	1.277***	(0.277)	0.836	(0.553)	1.291***	(0.299)
Seasonals?	Y		Y		Y	
Sample	Full		Full		Full	

Notes: Entries are cumulative structural impulse responses, with parametric bootstrap standard errors in parentheses. VARs fo r all indicated spreads are constrained to have the same coefficients, including the same impact coefficient. All VARs have 4 lags, exogenous seasonal controls, and are estimated in levels. The RIN price shock is identified by assuming it equals the RIN obl igation price innovation (RIN obligation ordered first in Cholesky factorization). Coefficients are significant at the *10% **5% ***1% level.

Table 6. Bivariate VARs for retail prices: cumulative structural IRFs, with RIN obligation ordered first

	E85-E10		E85-E10		E85-E10		Weekly E85-E10		E10	
Lag										
0	-0.013	(0.036)	-0.002	(0.036)	-0.001	(0.039)	-0.050	(0.070)	0.004	(0.012)
1	-0.043	(0.053)	-0.020	(0.054)	-0.017	(0.056)	0.068	(0.117)	0.011	(0.023)
2	-0.063	(0.064)	-0.029	(0.067)	-0.009	(0.066)	0.170	(0.159)	0.029	(0.033)
3	-0.039	(0.073)	0.004	(0.078)	0.025	(0.073)	0.203	(0.188)	0.027	(0.043)
4	-0.027	(0.076)	0.025	(0.084)	0.052	(0.075)	0.288	(0.212)	0.021	(0.052)
5	-0.019	(0.075)	0.040	(0.086)	0.071	(0.072)	0.308	(0.222)	0.011	(0.060)
6	-0.015	(0.074)	0.052	(0.086)	0.087	(0.069)	0.312	(0.222)	0.000	(0.066)
7	-0.011	(0.073)	0.064	(0.086)	0.102	(0.068)	0.297	(0.216)	-0.012	(0.071)
8	-0.008	(0.073)	0.074	(0.086)	0.117*	(0.069)	0.289	(0.214)	-0.024	(0.075)
9	-0.005	(0.074)	0.085	(0.087)	0.132*	(0.070)			-0.037	(0.080)
10	-0.001	(0.076)	0.094	(0.088)	0.147**	(0.071)			-0.050	(0.084)
11	0.002	(0.077)	0.104	(0.090)	0.160**	(0.072)			-0.063	(0.088)
12	0.005	(0.079)	0.113	(0.092)	0.173**	(0.074)			-0.076	(0.093)
13	0.007	(0.081)	0.122	(0.094)	0.186**	(0.076)			-0.089	(0.098)
14	0.010	(0.082)	0.130	(0.096)	0.198**	(0.077)			-0.102	(0.102)
15	0.012	(0.084)	0.138	(0.098)	0.209***	(0.079)			-0.115	(0.107)
Seasonals?	Y		N		N		N		Y	
Sample	Full		Full		2013		Full		Full	

Notes: Entries are cumulative structural impulse responses, with asymptotic standard errors in parentheses. For the E85-E10 spread, the variables are the spread and its net RIN obligation. For the E10 VAR, the variables are the E10 price and the D6 RIN price. All VARs with daily data are estimated in levels. The weekly VAR is estimated using end-of-week data, for weeks ending on Tuesdays, and is specified in first differences. The RIN price shock is identified by assuming it equals the RIN obligation price innovation (i.e. the RIN obligation ordered first in Cholesky factorization). Coefficients are significant at the *10% **5% ***1% level.

Table 7. Cumulative dynamic multipliers from distributed lag regressions of changes in spreads on changes in net RIN obligation

	Gulf diesel – Gulf jet	NY diesel – Rott'm diesel	U.S. Gulf diesel – Rott'm diesel	NY RBOB – Euro BOB	NY RBOB - Brent	Los Angeles RBOB - Brent	E85 – E10	E10
Lag								
0	0.674**	0.639**	0.493	0.645	1.216**	0.646	-0.012	0.007
	(0.287)	(0.265)	(0.330)	(0.503)	(0.511)	(0.713)	(0.025)	(0.029)
1	0.576**	0.960***	0.737*	0.553	1.431**	0.380	-0.025	0.019
	(0.242)	(0.355)	(0.378)	(0.636)	(0.648)	(0.754)	(0.040)	(0.047)
2	0.856***	0.673*	0.437	1.145	1.263*	0.563	-0.033	0.039
	(0.273)	(0.395)	(0.299)	(0.767)	(0.724)	(0.815)	(0.052)	(0.062)
3	0.609*	1.219***	1.006***	1.410	1.279*	-0.145	0.003	0.042
	(0.363)	(0.388)	(0.292)	(0.927)	(0.736)	(1.291)	(0.067)	(0.076)
4	0.724**	0.666	0.685**	1.042	0.757	0.427	0.052	0.037
	(0.293)	(0.482)	(0.348)	(0.908)	(0.740)	(1.258)	(0.071)	(0.087)
5	0.706**	0.719	0.565	1.924	0.847	0.472	0.031	0.017
	(0.327)	(0.463)	(0.366)	(1.263)	(0.854)	(1.350)	(0.069)	(0.098)
6	0.691*	0.429	0.520	2.401**	2.209**	0.466	0.044	0.007
	(0.396)	(0.662)	(0.368)	(1.120)	(0.930)	(1.579)	(0.071)	(0.106)
7	0.985***	0.708	1.098**	3.408**	2.385**	0.680	0.043	0.013
	(0.349)	(0.744)	(0.430)	(1.557)	(0.953)	(1.634)	(0.078)	(0.115)
8	0.954*	0.817	1.020**	3.245**	2.527**	1.106	0.049	0.003
	(0.536)	(0.725)	(0.488)	(1.437)	(1.001)	(1.777)	(0.096)	(0.123)
9	0.445	0.989	1.180***	3.708**	3.213***	0.109	0.091	0.015
	(0.479)	(0.794)	(0.425)	(1.565)	(1.054)	(1.966)	(0.093)	(0.130)
10	0.896**	0.621	0.836*	3.224**	1.841*	-1.076	0.132	0.011
	(0.438)	(0.752)	(0.475)	(1.596)	(1.012)	(2.037)	(0.091)	(0.134)
11	0.779*	0.478	0.379	2.263	1.620	-1.464	0.142	0.008
	(0.448)	(0.820)	(0.506)	(1.382)	(1.010)	(1.913)	(0.104)	(0.139)
12	1.132***	0.639	0.938	2.599*	2.443**	0.025	0.120	0.008
	(0.431)	(0.917)	(0.578)	(1.564)	(1.237)	(2.226)	(0.102)	(0.144)
13	1.221**	0.289	0.783	2.493*	2.498*	0.761	0.098	0.005
	(0.520)	(0.946)	(0.667)	(1.480)	(1.285)	(1.986)	(0.106)	(0.146)
14	0.845*	0.574	0.856	1.392	2.154	-0.754	0.147	-0.006
	(0.491)	(0.977)	(0.692)	(1.628)	(1.541)	(2.179)	(0.106)	(0.148)
15	1.363**	1.416	1.453**	2.164	2.552	-0.138	0.186*	-0.019
	(0.620)	(0.987)	(0.624)	(1.656)	(1.855)	(2.482)	(0.112)	(0.152)
Seasonals?	Y	Y	Y	Y	Y	Y	Y	Y
Sample	Full	Full	Full	Full	Full	Full	Full	Full

Notes: Entries are cumulative dynamic multipliers and standard errors from distributed lag regressions of the change in the spread on the change in the net RIN obligation (contemporaneous value and 15 daily lags), including seasonal controls. The data are daily and the full sample is Jan. 1, 2013 – March 10, 2015. Standard errors are Newey-West with 15 lags. Significant at the *10% **5% ***1% level.

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Table 8. Cumulative dynamic multipliers from constrained distributed lag regressions: Wholesale spreads

	Diesel		**Gasoline**		**Diesel and Gasoline**	
# spreads	3		3		6	
Lag						
0	0.597***	(0.219)	0.826**	(0.380)	0.712***	(0.266)
1	0.749***	(0.240)	0.766*	(0.448)	0.758***	(0.290)
2	0.630***	(0.211)	0.959**	(0.488)	0.794***	(0.300)
3	0.920***	(0.226)	0.838	(0.654)	0.879**	(0.349)
4	0.672***	(0.255)	0.731	(0.616)	0.702**	(0.355)
5	0.658**	(0.260)	1.030	(0.779)	0.844**	(0.411)
6	0.563*	(0.321)	1.667**	(0.756)	1.115***	(0.425)
7	0.918**	(0.358)	2.085***	(0.782)	1.501***	(0.434)
8	0.898**	(0.386)	2.217***	(0.810)	1.557***	(0.453)
9	0.876**	(0.410)	2.303**	(0.945)	1.590***	(0.549)
10	0.774*	(0.403)	1.291	(0.950)	1.033*	(0.565)
11	0.513	(0.401)	0.764	(0.936)	0.639	(0.544)
12	0.925**	(0.447)	1.714	(1.114)	1.319**	(0.632)
13	0.744	(0.478)	1.942*	(1.009)	1.343**	(0.597)
14	0.801*	(0.452)	1.035	(1.183)	0.918	(0.664)
15	1.380**	(0.574)	1.520	(1.460)	1.450	(0.888)
Seasonals?	Y		Y		Y	
Sample	Full		Full		Full	

Notes: Spread regressions in a given column are constrained to have the same distributed lags across spreads; seasonal coeffi cients are not constrained to be the same across spreads. Estimation is by constrained OLS. Standard errors are Newey -West (15 lags). Coefficients are significant at the *10% **5% ***1% level.

Appendix Tables

Table A-1a. Distributed lag regressions: Wholesale Gulf Diesel– Gulf Jet Fuel spread

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change (days):	5-day	5-day	5-day	5-day	1-day	1-day	1-day	5-day	1-day	5-day	1-day
Cumulative Impulse Response (SE) after lags:											
0					0.674**	0.672**	0.652**		0.642**		0.555
					(0.287)	(0.287)	(0.273)		(0.251)		(1.045)
1					0.576**	0.586**	0.537**		0.456*		0.616
					(0.242)	(0.258)	(0.238)		(0.236)		(0.923)
2					0.856***	0.850***	0.804***		0.915***		-0.127
					(0.273)	(0.272)	(0.266)		(0.204)		(0.972)
3					0.609*	0.549	0.544		0.881***		-1.423
					(0.363)	(0.358)	(0.353)		(0.275)		(1.343)
4					0.724**	0.736**	0.647**		0.750***		-0.064
					(0.293)	(0.302)	(0.306)		(0.270)		(1.370)
5					0.706**	0.680**	0.616*		0.783***		-0.474
					(0.327)	(0.326)	(0.316)		(0.264)		(1.331)
6					0.691*	0.588	0.586		0.847**		-1.083
					(0.396)	(0.428)	(0.374)		(0.344)		(1.323)
7					0.985***	0.929**	0.866***		0.922***		0.132
					(0.349)	(0.379)	(0.328)		(0.280)		(1.438)
8					0.954*	0.879	0.818*		0.871**		0.071
					(0.536)	(0.563)	(0.470)		(0.423)		(1.718)
9					0.445	0.351	0.294		0.299		-0.226
					(0.479)	(0.535)	(0.455)		(0.419)		(1.805)
10					0.896**	0.868*	0.736*		0.914***		-0.335
					(0.438)	(0.482)	(0.397)		(0.345)		(1.543)
RIN obligation$_t$	0.555***	0.558***	0.559***	0.535**				0.633***		-0.101	
	(0.212)	(0.209)	(0.204)	(0.223)				(0.211)		(0.684)	
RIN obligation$_{t-5}$		0.034	0.019								
		(0.242)	(0.254)								
Observations	551	551	551	551	549	549	549	253	251	298	298
Sample	Full	Full	Full	Full	Full	Full	Full	2013	2013	2014-15	2014-15
Sum of coeffs (se)	0.555	0.592	0.578	0.535	1.363	1.212	1.144	0.633	1.296	-0.101	-0.179
	0.212	0.306	0.320	0.223	0.620	0.698	0.463	0.211	0.416	0.684	1.989
F (seasonals)	4.726	4.620	4.169		2.871	1.988					
p-val (seas)	1.28e-05	1.80e-05	7.46e-05		0.00391	0.0460					
F (lags)		0.0194	0.00580		1.249	1.158	1.290		1.290		1.290
p-val (lags)		0.889	0.939		0.230	0.302	0.203		0.203		0.203
F (Brent)			0.169			1.159					
p-val (Brent)			0.845			0.327					

Notes: The data are daily and the full sample is Jan. 1, 2013 – March 10, 2015. All regressions are of the form of a transformed spread (five-day or one-day differences) on the value of the RIN obligation for that spread (five-day or one-day differences), either contemporaneous or contemporaneous and lags. The first differences distributed lag specifications have 15 lags, the first ten cumulative dynamic multipliers are reported, and the 15-day cumulative multiplier is reported as "Sum of coeffs"; in regression (6), the current through fifth lag of the change in Brent prices are also included. Standard errors are Newey-West with 15 lags. Significant at the *10% **5% ***1% level.

Table A-1b. Distributed lag regressions: Wholesale New York Diesel – Rotterdam Diesel Spread

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change (days):	5-day	5-day	5-day	5-day	1-day	1-day	1-day	5-day	1-day	5-day	1-day
Cumulative Impulse Response (SE) after lags:											
0					0.639**	0.554**	0.608**		0.385		1.088
					(0.265)	(0.270)	(0.265)		(0.280)		(0.804)
1					0.960***	0.853**	0.911***		0.665*		1.653
					(0.355)	(0.399)	(0.337)		(0.380)		(1.110)
2					0.673*	0.578	0.601		0.579*		0.360
					(0.395)	(0.445)	(0.370)		(0.320)		(1.502)
3					1.219***	0.875**	1.122***		1.013***		1.301
					(0.388)	(0.438)	(0.326)		(0.246)		(1.455)
4					0.666	0.281	0.545		0.735***		-1.043
					(0.482)	(0.570)	(0.463)		(0.279)		(2.934)
5					0.719	0.392	0.566		0.394		0.993
					(0.463)	(0.530)	(0.398)		(0.259)		(2.610)
6					0.429	-0.211	0.238		0.181		-0.600
					(0.662)	(0.733)	(0.590)		(0.348)		(3.790)
7					0.708	-0.065	0.476		0.556		-1.157
					(0.744)	(0.864)	(0.694)		(0.468)		(4.115)
8					0.817	0.182	0.546		0.601		-1.165
					(0.725)	(0.912)	(0.627)		(0.418)		(4.263)
9					0.989	0.343	0.678		1.057**		-2.497
					(0.794)	(1.025)	(0.714)		(0.453)		(4.305)
10					0.621	0.100	0.280		0.399		-1.681
					(0.752)	(0.993)	(0.656)		(0.472)		(4.334)
RIN obligation$_t$	0.714***	0.703***	0.672**	0.669***				0.579***		1.229	
	(0.234)	(0.254)	(0.279)	(0.185)				(0.146)		(1.078)	
RIN obligation$_{t-5}$		-0.119	-0.131								
		(0.516)	(0.525)								
Observations	551	551	551	551	532	532	532	253	242	298	290
Sample	Full	Full	Full	Full	Full	Full	Full	2013	2013	2014-15	2014-15
Sum of coeffs (SE)	0.714	0.583	0.541	0.669	1.416	0.630	0.827	0.579	0.969	1.229	-1.813
	0.234	0.665	0.701	0.185	0.987	1.315	0.759	0.146	0.506	1.078	4.836
F (seasonals)	0.886	0.854	0.865		0.593	0.604					
p-val (seas)	0.528	0.556	0.546		0.784	0.775					
F (lags)		0.0536	0.0623		1.276	1.212	1.263		1.263		1.263
p-val (lags)		0.817	0.803		0.213	0.258	0.221		0.221		0.221
F (Brent)			0.852			8.846					
p-val (Brent)			0.427			3.48e-09					

Notes: See the notes to Table A-1a.

Table A-1c. Distributed lag regressions: Wholesale Gulf Diesel – Rotterdam Diesel Spread

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change (days):	5-day	5-day	5-day	5-day	1-day	1-day	1-day	5-day	1-day	5-day	1-day
Cumulative Impulse Response (SE) after lags:											
0					0.493	0.437	0.475		0.283		0.841
					(0.330)	(0.354)	(0.325)		(0.338)		(0.943)
1					0.737*	0.657	0.706*		0.457		1.463
					(0.378)	(0.449)	(0.371)		(0.419)		(0.971)
2					0.437	0.348	0.393		0.399		0.290
					(0.299)	(0.388)	(0.283)		(0.281)		(0.933)
3					1.006***	0.702*	0.952***		1.018***		0.572
					(0.292)	(0.365)	(0.283)		(0.281)		(1.236)
4					0.685**	0.353	0.621*		0.506*		1.345
					(0.348)	(0.412)	(0.329)		(0.273)		(1.475)
5					0.565	0.230	0.492		0.261		1.712
					(0.366)	(0.357)	(0.350)		(0.282)		(1.638)
6					0.520	-0.085	0.435		0.216		1.169
					(0.368)	(0.417)	(0.349)		(0.345)		(1.264)
7					1.098**	0.368	1.001**		0.699		2.047
					(0.430)	(0.451)	(0.414)		(0.431)		(1.359)
8					1.020**	0.340	0.912**		0.494		2.687
					(0.488)	(0.503)	(0.437)		(0.387)		(1.701)
9					1.180***	0.515	1.061***		1.034***		1.056
					(0.425)	(0.532)	(0.384)		(0.396)		(1.561)
10					0.836*	0.307	0.709		0.555		1.810
					(0.475)	(0.580)	(0.431)		(0.429)		(1.821)
RIN obligation$_t$	0.689***	0.713***	0.689***	0.675***				0.659***		0.767	
	(0.159)	(0.158)	(0.166)	(0.127)				(0.126)		(0.507)	
RIN obligation$_{t-5}$		0.263	0.220								
		(0.194)	(0.175)								
Observations	551	551	551	551	532	532	532	253	242	298	290
Sample	Full	Full	Full	Full	Full	Full	Full	2013	2013	2014-15	2014-15
Sum of coeffs (SE)	0.689	0.976	0.909	0.675	1.453	0.608	1.294	0.659	0.996	0.767	2.520
	0.159	0.258	0.240	0.127	0.624	0.734	0.530	0.126	0.460	0.507	2.499
F (seasonals)	0.983	1.079	0.987		0.644	1.023					
p-val (seas)	0.448	0.376	0.445		0.740	0.417					
F (lags)		1.832	1.585		2.472	1.431	2.419		2.419		2.419
p-val (lags)		0.176	0.209		0.00163	0.128	0.00209		0.00209		0.00209
F (Brent)			1.065			10.67					
p-val (Brent)			0.345			0					

Notes: See the notes to Table A-1a.

Table A-1d. Distributed lag regressions: New York RBOB – Euro-BOB

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change (days):	5-day	5-day	5-day	5-day	1-day	1-day	1-day	5-day	1-day	5-day	1-day
Cumulative Impulse Response (SE) after lags:											
0					0.645	0.695	0.709		0.675		1.190
					(0.503)	(0.498)	(0.512)		(0.515)		(1.471)
1					0.553	0.519	0.660		0.563		0.290
					(0.636)	(0.582)	(0.657)		(0.779)		(1.122)
2					1.145	1.068	1.296*		1.486*		0.354
					(0.767)	(0.692)	(0.755)		(0.821)		(1.438)
3					1.410	1.466*	1.602*		1.868*		-0.173
					(0.927)	(0.840)	(0.929)		(1.049)		(1.914)
4					1.042	0.785	1.272		1.630*		-1.106
					(0.908)	(0.874)	(0.886)		(0.960)		(1.849)
5					1.924	1.611	2.198*		2.753**		-1.360
					(1.263)	(1.106)	(1.199)		(1.201)		(2.147)
6					2.401**	2.249**	2.721**		2.757**		1.673
					(1.120)	(0.997)	(1.150)		(1.265)		(2.151)
7					3.408**	2.920*	3.778**		4.632***		-2.218
					(1.557)	(1.504)	(1.511)		(1.568)		(2.116)
8					3.245**	2.548*	3.657**		4.136**		-0.077
					(1.437)	(1.337)	(1.443)		(1.631)		(2.325)
9					3.708**	3.210**	4.160***		4.794***		-0.715
					(1.565)	(1.453)	(1.509)		(1.607)		(2.414)
10					3.224**	2.650*	3.711**		4.485***		-1.384
					(1.596)	(1.575)	(1.492)		(1.533)		(2.552)
RIN obligation$_t$	1.449**	1.646***	1.720***	1.716**				1.743**		1.528*	
	(0.672)	(0.596)	(0.544)	(0.756)				(0.876)		(0.855)	
RIN obligation$_{t-5}$		2.099***	2.124***								
		(0.725)	(0.639)								
Observations	551	551	551	551	532	532	532	253	242	298	290
Sample	Full	Full	Full	Full	Full	Full	Full	2013	2013	2014-15	2014-15
Sum of coeffs (SE)	1.449	3.745	3.844	1.716	2.164	1.327	2.802	1.743	2.766	1.528	1.350
	0.672	1.200	1.049	0.756	1.656	1.598	1.464	0.876	1.529	0.855	2.945
F (seasonals)	1.223	1.033	1.172		0.690	0.915					
p-val (seas)	0.283	0.410	0.314		0.701	0.503					
F (lags)		8.378	11.06		1.608	2.310	1.648		1.648		1.648
p-val (lags)		0.00395	0.000941		0.0674	0.00348	0.0579		0.0579		0.0579
F (Brent)			4.798			4.332					
p-val (Brent)			0.00860			0.000283					

Notes: See the notes to Table A-1a.

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Table A-1e. Distributed lag regressions: New York RBOB – Brent

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change (days):	5-day	5-day	5-day	5-day	1-day	1-day	1-day	5-day	1-day	5-day	1-day
Cumulative Impulse Response (SE) after lags:											
0					1.216**	1.154**	1.338***		1.263**		1.406
					(0.511)	(0.499)	(0.497)		(0.539)		(1.139)
1					1.431**	1.381**	1.638**		1.482*		2.015*
					(0.648)	(0.609)	(0.645)		(0.777)		(1.089)
2					1.263*	1.169	1.556**		1.707**		0.699
					(0.724)	(0.710)	(0.702)		(0.830)		(1.063)
3					1.279*	0.936	1.655**		1.829**		0.847
					(0.736)	(0.678)	(0.741)		(0.882)		(1.337)
4					0.757	0.449	1.218*		1.598**		-0.780
					(0.740)	(0.716)	(0.719)		(0.755)		(1.757)
5					0.847	0.526	1.392*		1.544*		0.498
					(0.854)	(0.867)	(0.783)		(0.827)		(1.805)
6					2.209**	1.568*	2.846***		2.597**		3.482**
					(0.930)	(0.890)	(0.912)		(1.040)		(1.764)
7					2.385**	1.686*	3.129***		3.352***		1.421
					(0.953)	(1.010)	(0.927)		(1.082)		(2.044)
8					2.527**	1.842*	3.374***		3.680***		1.186
					(1.001)	(1.020)	(0.982)		(1.165)		(2.348)
9					3.213***	2.473**	4.155***		4.508***		2.109
					(1.054)	(1.078)	(1.023)		(1.160)		(2.483)
10					1.841*	1.311	2.867***		3.298***		0.304
					(1.012)	(1.107)	(0.912)		(0.970)		(2.650)
RIN obligation$_t$	1.649***	1.753***	1.744***	2.171***				2.324***		1.162	
	(0.615)	(0.566)	(0.558)	(0.605)				(0.691)		(0.979)	
RIN obligation$_{t-5}$		1.111***	1.022***								
		(0.316)	(0.306)								
Observations	551	551	551	551	549	549	549	253	251	298	298
Sample	Full	Full	Full	Full	Full	Full	Full	2013	2013	2014-15	2014-15
Sum of coeffs (SE)	1.649	2.864	2.767	2.171	2.552	1.498	4.040	2.324	3.906	1.162	4.920
	0.615	0.677	0.693	0.605	1.855	2.013	1.391	0.691	1.564	0.979	3.121
F (seasonals)	2.128	1.635	1.661		1.103	1.294					
p-val (seas)	0.0317	0.112	0.105		0.360	0.244					
F (lags)		12.39	11.18		2.196	2.342	2.436		2.436		2.436
p-val (lags)		0.000467	0.000883		0.00580	0.00298	0.00191		0.00191		0.00191
F (Brent)			0.393			3.385					
p-val (Brent)			0.675			0.00277					

Notes: See the notes to Table A-1a.

Table A-1f. Distributed lag regressions: Los Angeles RBOB – Brent

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change (days):	5-day	5-day	5-day	5-day	1-day	1-day	1-day	5-day	1-day	5-day	1-day
Cumulative Impulse Response (SE) after lags:											
0					0.646	0.507	0.813		0.749		0.425
					(0.713)	(0.711)	(0.691)		(0.746)		(1.808)
1					0.380	0.293	0.662		0.515		1.419
					(0.754)	(0.776)	(0.744)		(0.873)		(1.867)
2					0.563	0.434	0.952		0.595		3.545**
					(0.815)	(0.768)	(0.780)		(0.873)		(1.726)
3					-0.145	-0.535	0.359		-0.246		3.746*
					(1.291)	(1.262)	(1.222)		(1.206)		(2.115)
4					0.427	0.201	1.042		0.514		4.569
					(1.258)	(1.276)	(1.194)		(1.229)		(2.845)
5					0.472	0.432	1.191		0.390		6.129**
					(1.350)	(1.333)	(1.278)		(1.296)		(3.107)
6					0.466	0.142	1.294		0.253		6.500**
					(1.579)	(1.633)	(1.501)		(1.525)		(2.981)
7					0.680	0.595	1.637		1.145		4.474
					(1.634)	(1.656)	(1.568)		(1.673)		(4.457)
8					1.106	1.342	2.188		2.020		3.219
					(1.777)	(1.806)	(1.715)		(1.881)		(3.483)
9					0.109	0.376	1.293		1.364		1.226
					(1.966)	(2.085)	(1.857)		(1.931)		(4.517)
10					-1.076	-0.374	0.205		-0.039		1.603
					(2.037)	(2.102)	(1.910)		(1.918)		(5.611)
RIN obligation$_t$	0.443	0.463	0.344	1.013				0.764		2.530	
	(1.038)	(1.091)	(0.839)	(0.975)				(1.017)		(2.225)	
RIN obligation$_{t-5}$		0.209	0.497								
		(0.997)	(0.966)								
Observations	551	551	551	551	549	549	549	253	251	298	298
Sample	Full	Full	Full	Full	Full	Full	Full	2013	2013	2014-15	2014-15
Sum of coeffs (SE)	0.443	0.671	0.841	1.013	-0.138	0.631	1.660	0.764	1.374	2.530	3.752
	1.038	1.815	1.498	0.975	2.482	2.784	2.010	1.017	2.066	2.225	5.631
F (seasonals)	1.865	1.826	1.431		1.285	1.041					
p-val (seas)	0.0632	0.0697	0.180		0.249	0.404					
F (lags)		0.0438	0.265		2.267	2.316	2.656		2.656		2.656
p-val (lags)		0.834	0.607		0.00420	0.00335	0.000666		0.000666		0.000666
F (Brent)			5.814			5.030					
p-val (Brent)			0.00318			5.00e-05					

Notes: See the notes to Table A-1a.

Table A-2a. Distributed lag regressions: E85 – E10 spread

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change (days):	5-day	5-day	5-day	5-day	1-day	1-day	1-day	5-day	1-day	5-day	1-day
Cumulative Impulse Response (SE) after lags:											
0					-0.012	-0.014	-0.007		-0.008		-0.041
					(0.025)	(0.025)	(0.024)		(0.025)		(0.075)
1					-0.025	-0.027	-0.016		-0.009		-0.054
					(0.040)	(0.042)	(0.039)		(0.044)		(0.093)
2					-0.033	-0.032	-0.021		0.007		-0.180
					(0.052)	(0.054)	(0.052)		(0.051)		(0.158)
3					0.003	0.003	0.018		0.037		-0.108
					(0.067)	(0.068)	(0.067)		(0.077)		(0.176)
4					0.052	0.057	0.069		0.111		-0.191
					(0.071)	(0.069)	(0.068)		(0.073)		(0.201)
5					0.031	0.041	0.051		0.083		-0.165
					(0.069)	(0.066)	(0.064)		(0.067)		(0.227)
6					0.044	0.056	0.066		0.083		-0.097
					(0.071)	(0.068)	(0.065)		(0.066)		(0.246)
7					0.043	0.063	0.070		0.081		-0.019
					(0.078)	(0.075)	(0.071)		(0.073)		(0.261)
8					0.049	0.080	0.079		0.104		-0.095
					(0.096)	(0.092)	(0.085)		(0.086)		(0.312)
9					0.091	0.122	0.123		0.146*		-0.010
					(0.093)	(0.089)	(0.083)		(0.084)		(0.312)
10					0.132	0.160*	0.166**		0.171**		0.084
					(0.091)	(0.086)	(0.081)		(0.079)		(0.337)
RIN obligation$_t$	-0.035	-0.032	-0.033	0.004				0.019		-0.086	
	(0.047)	(0.047)	(0.043)	(0.049)				(0.053)		(0.144)	
RIN obligation$_{t-5}$		0.048	0.066								
		(0.047)	(0.043)								
Observations	551	551	551	551	535	535	535	253	244	298	291
Sample	Full	Full	Full	Full	Full	Full	Full	2013	2013	2014-15	2014-15
Sum of coeffs (SE)	-0.0352	0.0162	0.0326	0.00434	0.186	0.238	0.233	0.0190	0.293	-0.0864	-0.162
	0.0468	0.0825	0.0735	0.0491	0.112	0.108	0.0938	0.0528	0.0980	0.144	0.392
F (seasonals)	4.516	3.937	2.792		2.974	2.258					
p-val (seas)	2.49e-05	0.000153	0.00490		0.00290	0.0224					
F (lags)		1.055	2.381		1.455	1.582	1.876		1.876		1.876
p-val (lags)		0.305	0.123		0.117	0.0743	0.0233		0.0233		0.0233
F (Brent)			3.093			1.746					
p-val (Brent)			0.0462			0.108					

Notes: See the notes to Table A-1a.

Table A-2b. Distributed lag regressions: E10 (dependent variable is change in D6 RIN price)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change (days):	5-day	5-day	5-day	5-day	1-day	1-day	1-day	5-day	1-day	5-day	1-day
Cumulative Impulse Response (SE) after lags:											
0					0.007	0.004	0.023		0.034		-0.047
					(0.029)	(0.023)	(0.024)		(0.028)		(0.045)
1					0.019	0.016	0.047		0.070		-0.081
					(0.047)	(0.035)	(0.036)		(0.044)		(0.070)
2					0.039	0.038	0.078*		0.102*		-0.070
					(0.062)	(0.045)	(0.046)		(0.055)		(0.103)
3					0.042	0.042	0.091		0.119*		-0.094
					(0.076)	(0.056)	(0.056)		(0.064)		(0.147)
4					0.037	0.047	0.097		0.124*		-0.096
					(0.087)	(0.063)	(0.064)		(0.074)		(0.186)
5					0.017	0.037	0.088		0.120		-0.130
					(0.098)	(0.070)	(0.072)		(0.085)		(0.200)
6					0.007	0.035	0.089		0.129		-0.181
					(0.106)	(0.077)	(0.077)		(0.091)		(0.235)
7					0.013	0.061	0.107		0.145		-0.140
					(0.115)	(0.086)	(0.084)		(0.101)		(0.267)
8					0.003	0.072	0.110		0.146		-0.137
					(0.123)	(0.092)	(0.091)		(0.109)		(0.301)
9					0.015	0.090	0.134		0.174		-0.151
					(0.130)	(0.098)	(0.098)		(0.113)		(0.350)
10					0.011	0.093	0.140		0.184		-0.177
					(0.134)	(0.103)	(0.099)		(0.117)		(0.356)
RIN obligation$_t$	0.042	0.041	0.030	0.099				0.144**		-0.184	
	(0.081)	(0.085)	(0.053)	(0.061)				(0.068)		(0.183)	
RIN obligation$_{t-5}$		-0.018	0.021								
		(0.058)	(0.036)								
Observations	551	551	551	551	551	551	551	253	253	298	298
Sample	Full	Full	Full	Full	Full	Full	Full	2013	2013	2014-15	2014-15
Sum of coeffs (SE)	0.0420	0.0231	0.0509	0.0986	-0.0187	0.111	0.165	0.144	0.241	-0.184	-0.351
	0.0812	0.139	0.0848	0.0606	0.152	0.121	0.123	0.0679	0.141	0.183	0.504
F (seasonals)	5.721	5.502	4.446		5.348	3.581					
p-val (seas)	5.27e-07	1.07e-06	3.12e-05		1.78e-06	0.000466					
F (lags)		0.0919	0.330		1.575	1.354	1.376		1.376		1.376
p-val (lags)		0.762	0.566		0.0760	0.165	0.154		0.154		0.154
F (Brent)			48.12			21.21					
p-val (Brent)			0			0					

Notes: See the notes to Table A-1a.

EXHIBIT B

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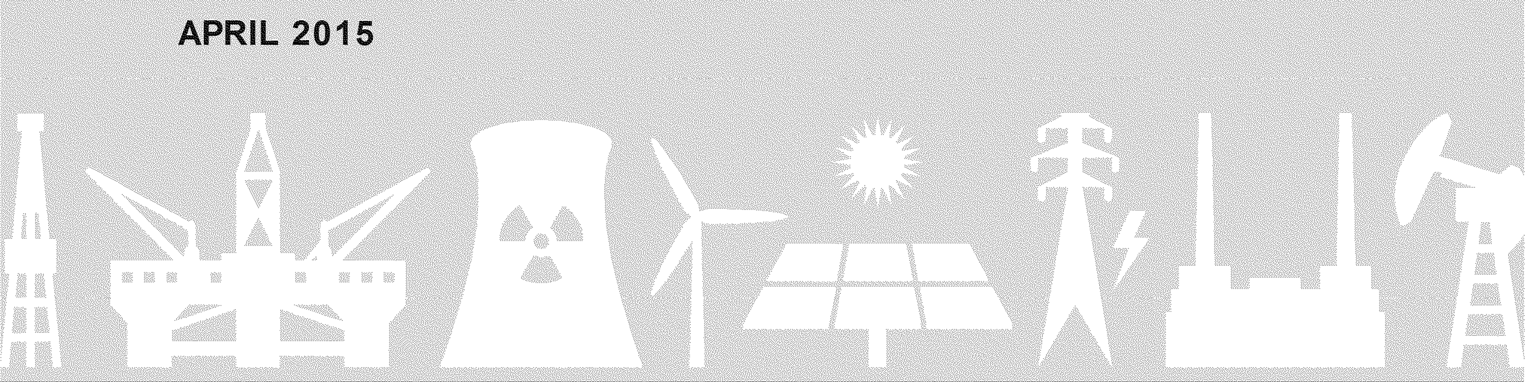
THE RENEWABLE FUEL STANDARD: A PATH FORWARD

JAMES H. STOCK

APRIL 2015



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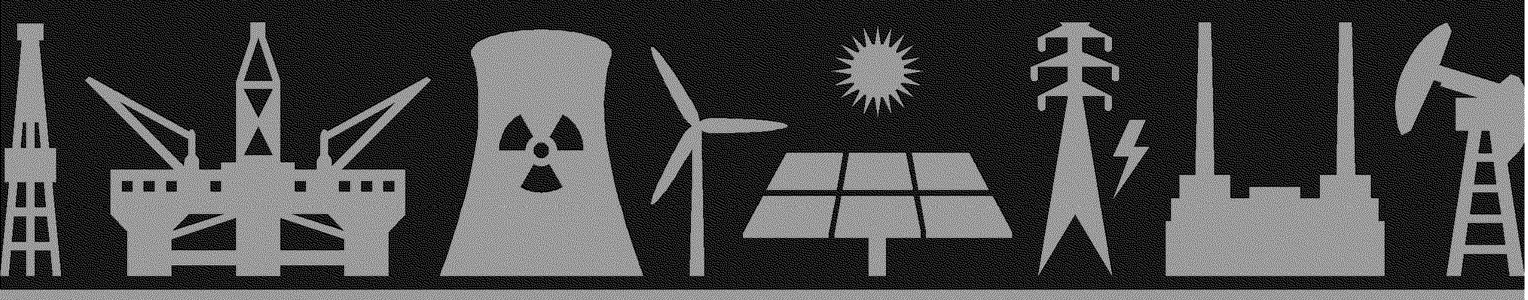

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THE RENEWABLE FUEL STANDARD: A PATH FORWARD

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APRIL 2015

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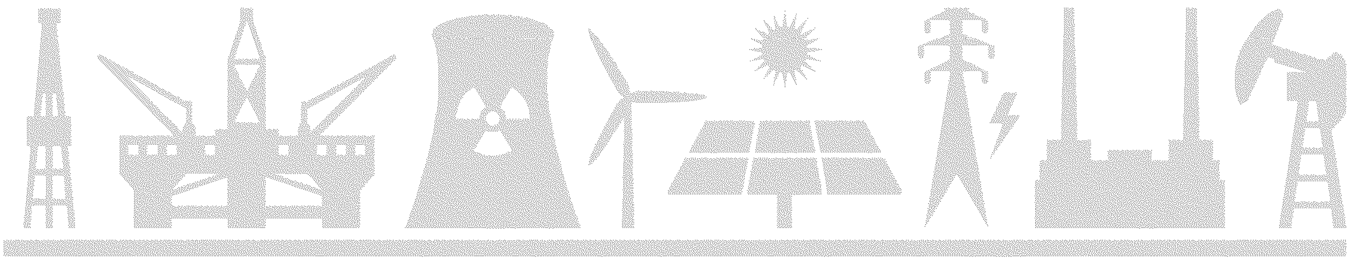

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EXECUTIVE SUMMARY

America's renewable fuels policy is at a crossroads. The Renewable Fuel Standard (RFS) is derided by some as an inefficient program that is driving up costs for fuel suppliers and a threat to motorists at the pumps, while others insist it is a valuable tool to reduce US dependence on foreign oil that will also pay future dividends in the fight against climate change. Developed initially in 2005 and expanded in the Energy Independence and Security Act (EISA) of 2007, the RFS seeks to reduce both greenhouse gas emissions and US dependence on oil imports by establishing increasing quantities of renewable fuels that must be blended into transportation fuels. In part because of the RFS, the volume of renewable fuels in the US surface transportation fuel supply more than doubled from 2007 to 2013. But even though the twin climate and energy security goals of the RFS remain as valid as when the EISA was enacted, today the RFS is facing multiple challenges. The current first-generation biofuels mainly use food crops as feedstock and are either expensive or have modest GHG improvements over petroleum fuels. The development and commercialization of low greenhouse gas second-generation biofuels—critical to the ultimate success of the program—has fallen far short of the very ambitious goals laid out in the EISA. Moreover, many cars are limited to gasoline with at most 10% ethanol (the dominant biofuel)—the so-called E10 blend wall—and in 2013 the amount of ethanol in the US fuel supply reached the E10 plateau. As a result, the RFS, and US biofuels policy more generally, has reached a critical point at which some energy industry leaders and policy makers have called for it to be reformed or even overturned. Yet the challenge of transitioning to a low-carbon transportation sector remains, and if anything is made both more difficult and more pressing because of low gasoline prices and the likely associated increase in consumption. Because the first-best option of a carbon tax combined with substantial early-stage research and development funding remains politically unlikely, it is important to keep options open by supporting research and investment in a wide range of low-carbon technologies.

This paper examines the economics of the RFS in order to understand the challenges it has faced since 2013 and takes a critical look at the choices currently facing the RFS and US biofuels policy. In brief, the RFS serves as a tax on petroleum fuels and a corrective subsidy to renewable fuels. As a matter of economics, such a system is justified when one of the fuels generates more costs not borne by its users (i.e. externalities) than does the other fuel. That is the case here: renewable fuels both reduce dependence on foreign oil and generate less greenhouse gas emissions than do petroleum fuels. Under the RFS, the subsidy to renewable fuels operates through the market for RFS compliance permits, which are called Renewable Identification Numbers (RINs). The fundamental driver of RIN prices is the difference in the price at which a renewable fuel can be produced and the price at which it can be sold, at a given mandated volume of the renewable fuel. Because RINs can be banked, the RIN price depends not only on this fundamental subsidy value in the current year, but on expectations of future fundamental subsidy values. These current and future subsidy values in turn depend on economic factors, such as the price of oil and the cost of producing biofuels, as well as on current and future RFS policy about the volume (or fraction) of renewable fuels in the fuel supply.

In summary, the paper finds:

- The current combination of RFS policy uncertainty, the E10 blend wall, high RIN prices, and low investment means that the RFS currently is imposing costs while failing to provide the future benefits associated with domestic, low-greenhouse gas, second-generation advanced biofuels. In theory, RIN prices provide support for and promote the use of renewable fuels. In practice, during 2013 and 2014, uncertainty surrounding RFS policy combined with the E10 blend wall has resulted in high RIN prices without seeing significant advances either in the amount of ethanol in the fuel supply or in accelerating investment in domestic, low-greenhouse gas, second-generation advanced liquid fuels. The result has been postponed investment,

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both in the development and production of advanced biofuels and in dispensing infrastructure for higher blends. At the same time, volatile RIN prices expose some refinersand importers to RIN price uncertainty while doing little to promote renewables.

- The RFS broadly faces three paths forward. One path is to maintain the status quo, but the status quo is both costly and ineffective. A second path is for EPA to reduce RIN prices by keeping mandated volumes away from the blend wall, using the legal tools provided under the EISA. While this path, if successful and credible, would reduce compliance costs, it would fail to promote the development of second-generation biofuels, which hold the promise of large greenhouse gas reductions. Indeed, current low oil prices will increase the demand for petroleum fuels and make the task of reducing carbon emissions in the transportation sector even more challenging and pressing. Just as natural gas is a transitional fuel in reducing carbon emissions in the electricity generation sector, second-generation biofuels might play a key transitional role in the transportation sector, but those fuels, technologies, and dispensing infrastructure must first be developed.

- The third path is for EPA to expand the renewable content of the fuel supply, consistent with the policy goals of the EISA. The challenge for this third path is how it can be achieved while controlling its costs. Because the two main drivers of those costs are policy uncertainty and the blend wall, implementation of this path requires combining policy clarity and commitment with a credible set of steps to expand the ethanol content of the fuel supply.

- All three of these possible paths present risks, but only the final path holds out the possibility of providing economically efficient support to second-generation biofuels. Nobody knows whether second-generation biofuels will play a large role in reducing the carbon footprint of the transportation sector and in reducing US dependence on foreign oil, but by maintaining economically efficient support for those fuels, policy decisions today can maintain the option that those technologies will develop and one day play such a role.

- Intrinsic limitations of the RFS suggest that this third path is most likely to succeed if it is coupled both with reforms to the RFS and with additional steps outside the RFS. The goals of these reforms are to increase policy certainty, to promote the sales of higher blends, to reduce RIN price volatility, and to increase the economic efficiency of the RFS. Some of the reforms to the RFS could be implemented administratively, while others are likely to require legislation. These potential reforms are discussed in the final section of the paper.

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INTRODUCTION

The US Renewable Fuels Standard (RFS) has come under attack from many sides over the past eighteen months. The RFS has been variously accused of driving up fuel costs for US motorists and creating uncertainty about compliance costs for some petroleum refiners and importers.[1] Developed initially in 2005 and expanded in the Energy Independence and Security Act (EISA) of 2007, the RFS seeks to reduce both greenhouse gas emissions and US dependence on oil imports by establishing increasing quantities of renewable fuels that must be blended into transportation fuels.[2] Supporters of the program point out that the United States now consumes approximately one million barrels per day of biofuels, thereby displacing imported oil, that they have lower life-cycle greenhouse gas emissions than petroleum gasoline, and that second-generation advanced biofuels from nonfood sources hold the promise of large greenhouse gas reductions in the future.

Many of the current concerns about the RFS stem from the fact that in 2013 the United States reached the point at which ethanol comprised 10% of the US gasoline supply. The dominant US gasoline blend, E10, contains at most 10% ethanol, the maximum that many cars can accept under the manufacturer's warrantee. As discussed below, the challenges posed by this so-called E10 blend wall underlie the sharp increases in the cost of complying with the RFS, relative to 2012 and earlier. In addition, the unwieldy structure of the RFS generates policy uncertainty by requiring EPA to make annual rulemakings that set out the fraction of renewable fuels in the US fuel supply.[3] The 2013 final rule appeared in August 2013, more than eight months into the compliance period, and in November 2014 EPA announced that the 2014 final rule will appear in 2015.[4] The increased costs arising from the blend wall and policy uncertainty have generated extensive debate about the direction of future policy both for the RFS and for biofuels policy more generally. Combined, these factors have led to calls from some policy makers and analysts, along with many in the fuel supply business, to revise or even repeal the RFS requirements.

Despite these concerns and the many changes in the US economy and fuels markets since 2007, the twin policy goals of the EISA—reducing GHG emissions and reducing oil imports—remain as valid today as they did in 2007. Recent experience and additional scientific knowledge reinforce the imperative of moving toward a low-carbon economy, and one of the most challenging parts of that transition is reducing the carbon emissions in the transportation sector. Moreover, even though net oil imports are half what they were in 2005,[5] further reducing net petroleum imports reduces the economy's exposure to oil supply shocks of foreign origin: reducing oil imports through domestically produced biofuels enhances macroeconomic energy security.[6]

The RFS—and with it, US biofuels policy more generally—has thus reached a crossroads. While the first-best policy would be to replace the RFS with a carbon tax combined with significantly higher government R&D support for low-carbon transportation fuels, this option is not politically viable at present. Further, although there have been calls for repeal of the RFS, repeal alone would leave the United States with very limited ways to provide ongoing support for the development and use of domestic low-carbon fuels.

Broadly speaking, therefore, RFS policy could follow three paths. The first path is to continue the flexible, short-run focus in the annual rulemakings, so that annual renewable fuel requirements can be adjusted as policy goals evolve. The second path is to commit to a conservative approach that stays within the E10 blend wall while attempting to support low-carbon domestic advanced biofuels (such an approach was laid out in EPA's proposed 2014 RFS rule). The third path is to commit instead to an ambitious plan for expanding both conventional and advanced biofuels.

This paper has three goals. The first is to provide an accessible discussion of the economics of the RFS. The second is to draw on this economic discussion and recent experience with the RFS to analyze these three policy paths. The third is to lay out potential reforms to the RFS, both administrative within current law and reforms that would require legislative action, and to discuss additional biofuels policy steps that would complement the reforms to the RFS and would support the goals of biofuels policy in an economically efficient way.

In brief, among these three policy paths, the first provides maximum flexibility. Recent experience suggests, however, that the resulting policy uncertainty would likely lead both to high compliance costs and to low investment in advanced fuels and in the infrastructure that would support greater volumes of renewable fuels (especially ethanol) in the marketplace. Thus this first path is likely to be both costly and ineffective. The second path—commit to a conservative approach to the E10 blend wall—could, in theory, result in low compliance costs. However, the annual nature of the rulemakings combined with legal risk suggests that credible commitment to a conservative path could prove very difficult. In practice this path, like the first, would likely lead to policy uncertainty and high compliance costs without investment. Moreover, this path does not promote the development of additional ethanol infrastructure that would facilitate the long-term ability of new low-GHG sources of ethanol to enter the market. The third path would entail a conscious decision to expand ethanol consumption beyond the E10 blend wall through higher ethanol blends, in particular E85.[7] But because this path would entail a substantial increase in volumes of renewable fuels, by itself it runs the risk of high and economically inefficient compliance costs.

The analysis in this paper suggests that the third expansive path is the most likely to achieve the twin goals of promoting low-carbon domestic advanced fuels and enhancing macroeconomic energy security. Because there currently is no clear best low-carbon technology for the transportation sector, it is important to keep options open by supporting research and investment in a wide range of low-carbon technologies—including second-generation biofuels. The recent decline in oil prices underscores the importance of supporting this research and investment because of the currently high costs of many alternatives to petroleum in the transportation sector, and because low gasoline prices (if they persist) are likely to increase US gasoline consumption. But this likely expansion of gasoline consumption also provides a window in which the E10 blend wall is less pressing.

Given the unlikely prospect of broadly expanding federal research support for low-carbon transportation technologies (or for other first-best climate policy solutions such as a carbon tax), the RFS is the main tool available for supporting development and commercialization of advanced biofuels. But to be successful in promoting advanced biofuels and for it to be viable in the long run, RFS policy must be economically efficient. Perhaps paradoxically, I argue that this third path has the potential to achieve low long-run compliance costs and, of the three, to be the most economically efficient in the long run because it is the most likely to bring forth the investments that will relieve the underlying source of pressure on compliance costs produced by the E10 blend wall.

Because of the structural limitations of the RFS, this third path is most likely to be effective and economically efficient if coupled with a program of initiatives and reforms to biofuels policy both within and outside of the RFS. The paper therefore concludes with a list of such reforms: administrative reforms within the existing legal framework, legislative reforms to the RFS, and various non-RFS policy steps, including actions that can be taken by the biofuels industry, that would advance biofuels policy goals while promoting economic efficiency.

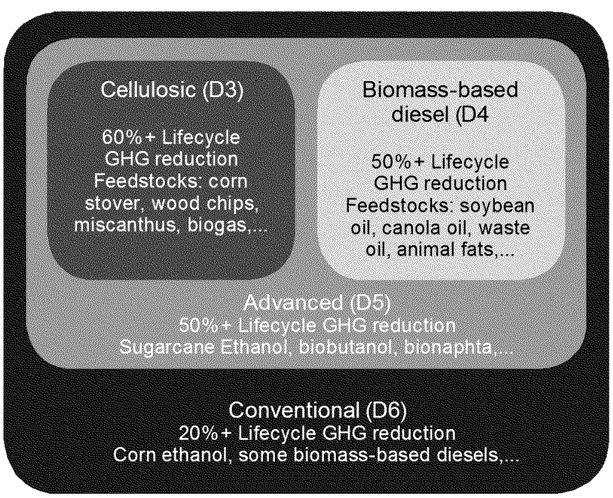
The remainder of this paper develops these arguments. The paper begins by reviewing how the RFS works and the history of biofuels production under the RFS, followed by a discussion of the economics of the RFS. The paper then turns to an analysis of the three paths and concludes with a discussion of potential reforms to the RFS program and additional policy options.

MECHANICS OF THE RFS

The EISA specifies volumetric requirements, or Renewable Volume Obligations (RVOs), for renewable fuels to be blended into US surface transportation vehicle fuels, which are subject to adjustment by the EPA under certain conditions, or waiver authorities (discussed later). The act requires EPA to set annual standards through annual rulemakings. Although the statutory requirements are volumetric, enforcing volumetric requirements is not practical. Instead, the EPA sets the standards as fractional obligations, computed as the volumetric requirement divided by the Energy Information Administration's projection of total petroleum gasoline plus diesel surface transportation fuel consumption (excluding Alaska and an exemption for small refineries).Compliance with the RFS is achieved using EPA'ssystem of Renewable IdentificationNumbers (RINs).

RFS fuel categories. As shown in Figure 1, the RFS divides renewable fuels into four nested categories: total renewable, advanced, biomass-based diesel (BBD), and cellulosic. Under the EISA, each of these four categories has its own volumetric requirements, which the EPA translates into four corresponding fractional requirements through annual rulemakings. These categories are defined in terms of their reductions in life-cycle emissions of greenhouse gasses (GHGs), relative to petroleum, in terms of their feedstock, and in of their fuel characteristics.

Figure 1: The RFS fuel nesting scheme



Source: EPA

Total renewable fuels comprise conventional biofuels and advanced biofuels. Conventional biofuels must achieve a 20% reduction in life-cycle greenhouse gas (GHG) emissions, relative to petroleum fuels, on an energy-equivalent basis. The dominant conventional fuel is ethanol made from corn starch, although recently some conventional biomass-based diesel has entered the fuel supply. To qualify as an advanced biofuel, the fuel must achieve at least a 50% life-cycle GHG reduction—60% in case of cellulosic fuels—relative to the gasoline or diesel fuel that it replaces. The advanced biofuels category has three subcategories: biomass-based diesel, cellulosic fuels, and a residual comprised of other biofuels with a 50% GHG reduction.

- The biomass-based diesel category consists of diesel biofuels that achieve the 50% reduction threshold. Biomass-based diesel feedstocks include soy and other vegetable oils, waste cooking oil, and animal fats. Biomass-based diesel comprises biodiesel and renewable diesel, which are produced using different chemical processes.[8] In this paper, the term "biomass-based diesel" refers to this subcategory of advanced fuels, and conventional biomass-based diesel refers to biomass-based diesel that achieves between a 20% and 50% GHG reduction and therefore qualifies as a conventional (but not advanced) biofuel.

- Cellulosic biofuels are required to have at least a 60% life-cycle GHG reduction relative to petroleum fuels. Cellulosic feedstocks include corn stover (the nonkernel waste left after harvesting corn), wood chips, energy plants such as miscanthus, and other woody nonfood sources. These fuels are in early research or pilot stages, and the first domestic commercial-scale cellulosic ethanol plants are now opening.[9] The EPA has also qualified natural gas produced by landfills, municipal wastewater treatment facilities, and agricultural digesters as a cellulosic fuel when used for transportation.[10]

- The remaining "other" category consists of

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nondiesel, noncellulosic biofuels that achieve a 50% GHG reduction. Historically, the main fuel in this category has been imported Brazilian sugarcane ethanol.[11]

Statutory volumes and annual EPA rulemakings. The EISA specifies in statute RVOs for total renewable, total advanced, and cellulosic biofuels, and provides EPA with authority to waive those statutory RVOs under certain conditions. The statute also sets a floor for the biomass-based diesel RVO but leaves setting that RVO to EPA discretion, subject to specific guidance.

- The cellulosic waiver authority authorizes EPA to reduce the cellulosic RVO by the amount of a projected shortfall of cellulosic production below the statutory cellulosic RVO and, optionally, to reduce the total advanced and total renewable RVOs by up to the amount of the cellulosic shortfall.[12]

- The general waiver authority allows EPA to waive any of the volumes if it finds either that failing to do so would cause severe economic harm or if there is inadequate domestic supply of the relevant fuel.[13]

- The EISA specifies that the biomass-based diesel RVO must be at least one billion wet gallons, but leaves it to the EPA to set the RVO by weighing six statutorily specified criteria: (i) impact on the environment, including both climate change and local environmental effects such as water quality; (ii) the impact of renewable fuels on energy security; (iii) the expected annual rate of future commercial production of biomass-based diesel; (iv) the impact of renewable fuels on infrastructure and the sufficiency of infrastructure to deliver renewable fuels; (v) the impact of the use of renewable fuels on the cost to consumers of transportation fuel and on the cost to transport goods; and (vi) other factors including job creation, price of agricultural commodities, rural economic development, and food prices.[14]

- EPA's annual determination of the cellulosic RVO is guided both by the statute and a 2013 ruling by the US Court of Appeals for the District of Columbia. The court found that EPA had set the 2012 standard in a way that would tend to overestimate actual volumes and that doing so was inconsistent with the statute, which the court interpreted as requiring EPA to set the cellulosic RVO using a "neutral methodology" aimed at providing a prediction of "what will actually happen" regarding cellulosic production in the compliance year.[15]

Table 1 lists the statutory RVOs and the RVOs set by EPA in its annual rulemakings. Because cellulosic production has fallen far short of the statutory volumes, EPA has exercised the cellulosic waiver authority every year since 2010 but has only used it to reduce the cellulosic obligation, not the total advanced or total renewable RVOs. The final column in both blocks of Table 1 shows the implied volume of the conventional biofuels pool, which is the difference between the total renewable obligation and the total advanced obligation. The EISA capped this volume at 15 billion gallons (Bgal), reflecting the role of corn ethanol as a transitional fuel – one that delivers energy security benefits but relatively limited GHG benefits – to lower-GHG second-generation advanced and cellulosic biofuels.[16]

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Table 1: RFS volumes: statutory and annual EPA rulemakings

	Statutory Volumes (Billions of gallons)					As Set by EPA Rule-Making (Billions of gallons)				
Year	Cellulosic	Biomass-based Diesel	Total Advanced	Total Renewable	Implied Conventional Pool	Cellulosic	Biomass-based Diesel	Total Advanced	Total Renewable	Implied Conventional Pool
2009	n/a	0.5	0.6	11.1	10.5	n/a	0.5	0.6	11.1	10.5
2010	0.1	0.65	0.95	12.95	12	0.00065	0.65[e]	0.95	12.95	12
2011	0.25	0.8	1.35	13.95	12.6	0.006	0.8	1.35	13.95	12.6
2012	0.5	1	2	15.2	13.2	0.0105[c]	1	2	15.2	13.2
2013	1	≥1.0[a]	2.75	16.55	13.8	0.0008[d]	1.28	2.75	16.55	13.8
2014	1.75	≥1.0[a]	3.75	18.15	14.4					
2015	3	≥1.0[a]	5.5	20.5	15					
2016	4.25	≥1.0[a]	7.25	22.25	15					
2017	5.5	≥1.0[a]	9	24	15					
2018	7	≥1.0[a]	11	26	15					
2019	8.5	≥1.0[a]	13	28	15					
2020	10.5	≥1.0[a]	15	30	15					
2021	13.5	≥1.0[a]	18	33	15					
2022	16	≥1.0[a]	21	36	15					
2023	b	b	b	b	b					

Notes: Units are billions of RIN gallons for cellulosic, total advanced, and total renewable, and billions of wet gallons for BBD. The "Implied conventional pool" is the difference between the volumes in the total renewable and total advanced pools. [a] Statute sets floor of 1.0 Bgal, actual mandate to be determined by EPA through annual rulemaking. [b] To be determined by EPA through a future rulemaking. [c] The 2012 cellulosic volume was vacated by a Jan. 25, 2013 ruling of the US Court of Appeals for the District of Columbia, which stated that EPA did not but must apply a "neutral methodology" for determining the cellulosic RVO. See the 2013 rule preamble for a discussion, 78 FR 49800-49801. [d] Reduced to 0.8 mgal in May 2014, from 6 mgal in the 2013 final rule, in response to petitions from the American Petroleum Institute and American Fuel and Petrochemical Manufacturers (79 FR 25025). [e] The 2009 and 2010 biomass-based diesel standards were implemented together, for total BBD of 1.15 by the end of 2010 (75 FR 14670). Source: Congressional Research Service, Environmental Protection Agency.

Finally, if EPA waives a specific statutory volume by more than 20% for two consecutive years, or by more than 50% for one year, it must promulgate a modified table of prospective volumes for the affected category.[17] Accordingly, EPA will need to reestablish the table of cellulosic volumes starting in 2016. As discussed below, calculations suggest that EPA will need to reestablish the total advanced table of volumes in 2017 and the total renewable table of volumes in 2018.

Compliance through the RIN system. The compliance mechanism for the RFS is the Renewable Identification Number (RIN) system. By EPA regulation, refiners and importers, referred to as "obligated parties," are required to turn in (retire) RINs when they sell petroleum gasoline or petroleum diesel into the domestic surface transportation market. RINs are generated upon production or import of a qualifying renewable fuel and are typically separated from that fuel when it is blended or sold into the fuel supply. Detached RINs are tradable, so an obligated party can acquire RINs for compliance either by purchasing the renewable fuel with the RIN attached or by purchasing RINs on the secondary RIN market. Each of the four categories of fuels in Figure 1 generates its own RINs. For example, cellulosic ethanol generates a D3 RIN, biodiesel generates a D4 RIN, sugarcane ethanol (an advanced, noncellulosic, non-BBD fuel) generates a D5 RIN, and corn ethanol generates a D6 RIN. In 2013, for each gallon of nonrenewable fuel, the obligated party was required to hand 0.0812 D6 RINs, 0.0049 D5 RINs,

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0.0113 D4 RINs, and 0.00004 D3 RINs (a total of 0.0974 RINs),[18] which will be referred to as the "RIN bundle" that must be turned in per gallon of petroleum fuel.

Excess D3 and D4 RINs can be used to satisfy the D5 and D6 requirements, and excess D5 RINs can be used to satisfy the D6 requirement. The number of RINs generated per gallon of renewable fuel is based on the energy equivalence value, relative to ethanol. Thus blending a gallon of ethanol generates one RIN; blending a gallon of biodiesel generates 1.5 RINs, and a gallon of nonester renewable diesel generates 1.7 RINs because those biodiesels have a higher energy density than ethanol. Thus there is a distinction, in RFS parlance, between the "wet" (actual physical) gallons of the fuel and the RIN-equivalent gallons. For example, a wet gallon of biodiesel generates 1.5 RIN gallons.

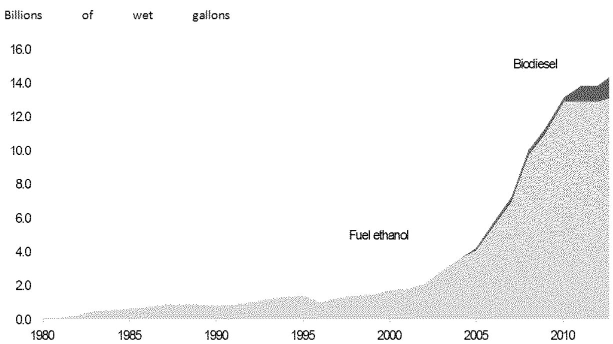
RINs are tradable and, subject to some restrictions, durable. For example, RINs generated in 2012 can be used to meet compliance obligations in 2011, 2012, or 2013 (although banked 2012 RINs cannot exceed 20% of the 2013 RVO). Because of this overlapping, tradable structure, a RIN can be thought of as having an indefinite lifetime, subject to the rollover cap.[19] Being able to bank RINs provides a buffer to fluctuations in supply and demand, such as a drought or an unexpected increase in the demand for gasoline.

Because of the small volumes of cellulosic fuels initially anticipated in the EISA, the statute instructs EPA to make available cellulosic waiver credits with which obligated parties can fulfill their cellulosic obligations. The only explicit restriction on RIN prices in the EISA concerns a statutory cap on the price of cellulosic waiver credits, which, when combined with a D5 RIN, can be used to satisfy the D3 RIN requirement. The cap on the price of the cellulosic waiver credit thus caps the spread between the D3 and D5 RINs. This cap is indexed to the price of gasoline and for 2013 was $0.42.[20]

BIOFUELS CONSUMPTION AND THE BLEND WALL

Over the past ten years, the biofuel content of the US fuel supply has risen from less than 2 billion gallons in 2000 to more than 14 billion gallons in 2013. As Figure 2 shows, most of that growth has been in ethanol (primarily corn ethanol and some cane ethanol). The sharp increase in ethanol consumption over the past decade is a result of several factors, including the phasing out of MTBE as an oxygenate and its replacement with ethanol as well as state and federal biofuels policy (including the ethanol blenders' tax credit and the RFS).

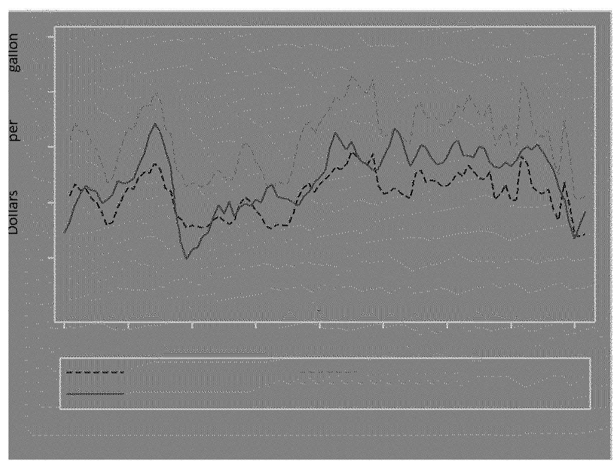
Figure 2: U.S. fuel ethanol and biodiesel consumption, 1981-2013



Source: EIA

US ethanol prices have historically moved with gasoline prices. As is shown in Figure 3, since 2007 the wholesale price of corn ethanol has typically been below the price of wholesale petroleum gasoline (RBOB)[21] on a volumetric basis, but above the petroleum gasoline price after adjusting for ethanol having only 68% the energy content of petroleum gasoline per gallon. Making precise inferences from these data either about the effect on retail gasoline prices of blending ethanol or on the underlying actual cost of production of ethanol faces two difficulties. First, because ethanol is used to boost octane and replaces petroleum octane boosters, it is competing both with gasoline on an energy basis and with the octane boosters, enhancing the value of ethanol. Second, the price of traded ethanol is influenced by a host of subsidies and policies, complicating the relationship between the production cost of ethanol and the wholesale traded price of ethanol. During the period after the expiration of the volumetric ethanol excise tax credit on December 31, 2012, and before high RIN prices in February 2013—when ethanol was approximately 10% of gasoline and was not receiving a direct subsidy from either the tax credit or the RFS—ethanol prices averaged approximately 20% less than wholesale gasoline on a volumetric basis, and approximately 15% more on an energy-adjusted basis. This episode happened to coincide with the drought of 2012, and during the first six months of 2012, before the severity of the drought became clear later in the summer, the price of ethanol was nearly 30% less than petroleum gasoline on a volumetric basis, and 5% above on an energy-adjusted basis. Using data through 2010, Knittel and Smith (2012) estimate that ethanol blending decreased US gasoline prices by up to $0.10 per gallon. Since the summer of 2014, ethanol prices have fallen with gasoline prices.

Figure 3: Price of wholesale gasoline and ethanol on an energy-equivalent basis



As can be seen in Figure 2, the composition of biofuel consumption has changed since 2010. These changes are largely a consequence of the E10 blend wall, the RFS, and various biofuels tax credits.

The EISA statutory volumes hit the E10 blend wall several years earlier than expected based on gasoline consumption projections at the time the EISA was developed and

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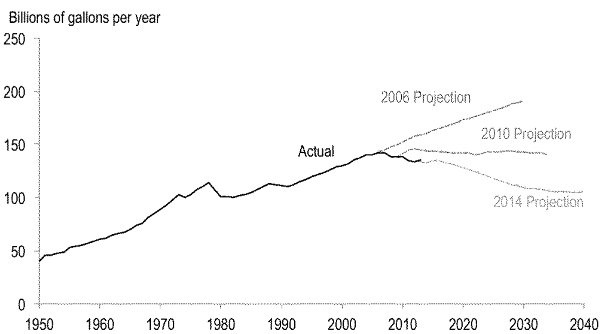
passed. As Figure 4 shows, the "reference scenario" in the EIA 2006 *Annual Energy Outlook* projected US gasoline consumption to grow into the indefinite future. But as a result of the Great Recession, new vehicle fuel economy standards, high gasoline prices, and possible changes in driving habits, total gasoline consumption has fallen, not increased, and the EIA's current estimate of 2014 gasoline consumption (including blended ethanol) is 137 billion gallons (Bgal), 15% below the 161 Bgal in the 2014 reference scenario projection in the EIA's 2006 *Annual Energy Outlook*. Based on the 2006 EIA projection, the 2014 E10 blend wall would be at approximately 16.1 Bgal of ethanol, whereas based on current estimates, it is at 13.7 Bgal, 2.4 Bgal less than based on the 2006 forecast.

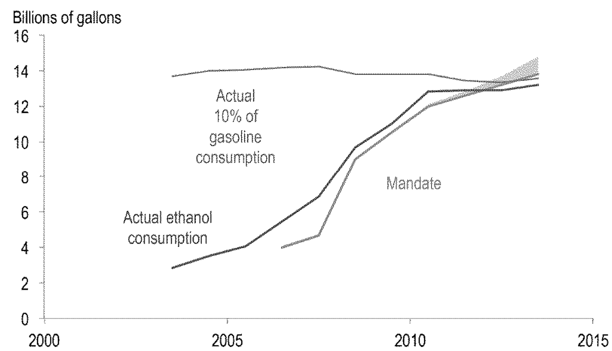
Figure 4: U.S. Consumption of Motor Gasoline, 1950-2040 (Actual and projected using EIA *Annual Energy Outlook* reference scenarios)



Source: AEO 2006, AEO 2010, AEO 2014, EIA.

If the conventional RVO exceeds 10% of gasoline consumption, then the conventional RVO cannot be filled by corn ethanol blended into E10 alone. This is the situation commonly referred to as the RFS mandate exceeding the E10 blend wall, although as discussed below this is more accurately not a "wall" but rather a situation in which additional ethanol must be provided through higher blends.[22] Through 2012, production and consumption of corn ethanol exceeded the RFS conventional mandate, that is, the conventional mandate did not bind. Figure 5 shows the relation between implied mandated ethanol consumption (shown as a range that adds statutory cellulosic volumes to the statutory conventional RVO), actual ethanol consumption, and 10% of actual gasoline consumption. In 2013, the conventional RVO of 13.8 billion gallons constituted 10.3% of gasoline consumption, exceeding the E10 blend wall. Because of very low penetration of higher blends, the resulting conventional biofuels shortfall was met through a combination of RINs banked from consumption in excess of the RVO in previous years, D4 and D5 RINs that were produced in excess of their respective RVOs, and D6 RINs generated by nonethanol conventional fuels.[23] In 2014 the statutory conventional RVO increases to 14.4 Bgal and, as shown in Table 1, it reaches its cap of 15 Bgal in 2015. That 15 Bgal cap is nearly 11% of currently projected gasoline consumption and exceeds the ethanol capacity of E10 by roughly 1.3 Bgal.

Figure 5: U.S. ethanol and gasoline consumption



Source: AEO 2006, Energy Independence and Security Act of 2007.
Note: The lower bound of the shaded region is the conventional mandate. The upper bound adds the statutory cellulosic mandate.

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ECONOMICS OF THE RFS

The RFS provides a guarantee to biofuel producers that they will be able to sell up to the mandated volume for a given year. If the biofuel can be produced for less than the price of its petroleum alternative and if there are no non-price market failures or other impediments to the consumption of renewable fuels, then that fuel will enter the fuel supply for price reasons, not because it is required to by the RFS. If, however, the marginal cost of producing the biofuel exceeds what consumers are willing to pay, then a subsidy is needed to make sure the fuel is produced and consumed. Because RINs are separated by blending a biofuel into the fuel supply, and RINs must be turned in to the EPA when an obligated party (a refiner or importer) sells petroleum fuel into the fuel supply, the price of a RIN is the vehicle for transferring corrective production subsidies to ensure that biofuels are produced and consumed at the mandated level. By the same token, the price of RINs is a measure of the compliance cost of the program: the greater is the RIN price, the greater is the value of the RINs that the obligated party must turn in. For these reasons, understanding the theory and empirical behavior of RIN prices is central to understanding the economics of the RFS.

This section examines the theory and empirical evidence concerning RIN prices. It begins with a discussion of the fundamental determinants of RIN prices in both static and dynamic (bankable) settings. It then turns to the effect of RIN prices on final transportation fuels, both in theory and empirically. In theory, the cost of RINs should be passed through to consumers, increasing the price of fuels with low renewable content (like diesel, which on average contains roughly 3% renewables) and decreasing the price of fuels with high renewable content (like E85). Consistent with the theory, empirical evidence indicates that the price of diesel and petroleum gasoline (E0) rises with RIN prices, and the price of E10 does not vary with RIN prices. Theory also predicts that the price of E85 should fall when RIN prices rise, but the evidence suggests that there is incomplete pass-through of the RIN price subsidy to retail E85 prices, so that only part of the effective RIN subsidy for E85 is passed along to the consumer.

RIN PRICE DETERMINATION[24]

The price of RINs, like other assets, depends on underlying fundamentals. For RINs, the fundamental is the difference between the price necessary to produce and distribute the mandated quantity of the relevant biofuel and the price the consumer is willing to pay for it. Because of the nested fuel structure of the RFS, RIN prices can further depend not just on market conditions for the fuel generating the RIN, but on markets for other biofuels. In addition, because the RIN is bankable, the price of a RIN today depends on expected future fundamental values as well as the fundamental values today. Because the fundamental values depend on the RFS mandated volume, the price of the RIN today depends on current RFS policy and on expected future RFS policy.

RIN price fundamentals and annual subsidy values. The fundamental factor in determining the RIN price is the value of the subsidy needed in a given compliance year to produce and consume the relevant biofuel at the mandated level. For the moment, suppose that RINs must be used in the year they are generated, and ignore interactions between fuels induced by the RFS nesting. The basic idea of the RIN price fundamental is that a biofuel producer receives two payments when she blends a gallon of biofuel: one for the physical product that the consumer uses as fuel, the other for the RIN that is generated and sold when the biofuel is blended. In equilibrium, the price at which the producer is willing to sell the RIN will just cover the marginal cost of producing the required volume. Thus the annual subsidy value, or RIN price fundamental, is determined by the difference between the price producers require for the marginal gallon of biofuel and the price consumers are willing to pay for it.

This RIN price fundamental is illustrated for biodiesel in Figure 6a. The price that a producer requires to produce the mandated volume is the price on the biodiesel supply curve (the "supply price") at that volume. This supply curve is upward-sloping because as more biodiesel is produced, feedstock costs (and perhaps other marginal production costs) go up. Similarly, the price that consumers are willing

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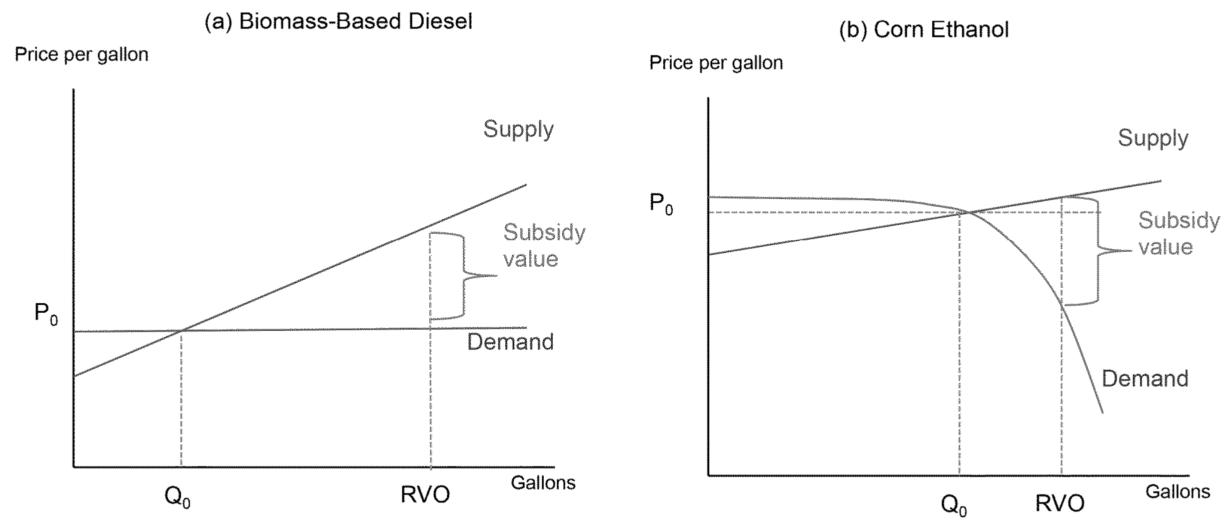
to pay is the price on the demand curve (the "demand price") at that volume. In the figure, this demand curve is flat at the price of petroleum diesel, so that at current volumes, biodiesel is in effect interchangeable with petroleum diesel. In the figure, the supply curve lies above the demand curve because biodiesel is more expensive than petroleum diesel. The difference between these two prices is the amount that must be covered by selling the

Figure 6: Biofuel supply and demand and subsidy values



RIN. Thus, the RIN price fundamental is the difference between the supply price and demand price as shown in Figure 6a, that is, the annual subsidy value.[25] In the case illustrated in the figure, the subsidy value flows to the biodiesel producer because consumers are indifferent between using diesel and biodiesel, but producers cannot afford to produce volumes greater than the market equilibrium Q_0 without a subsidy.[26]

Figure 6b provides a qualitative illustration of the corn ethanol market, in which the nonlinear demand curve for ethanol is a stylized representation of the blend wall. Below the equilibrium level $Q_{0,}$ demand is insensitive to price as long as the price of ethanol is less than the price of petroleum gasoline. But for volumes exceeding Q_0, it becomes increasingly difficult to put additional ethanol into the market, so that a sharply growing consumer subsidy is needed. In this sense, the blend wall is not so much a "wall" but an inflection point after which sharply increasing subsidies are need to ensure consumption of incremental gallons of ethanol. In the case illustrated—in which the RVO is in the blend wall portion of the demand curve—most of this subsidy flows to the consumer in the form of lower ethanol prices, since not much of a supply price increase is needed to induce the small additional amount of ethanol production.[27]

RIN price implications of the RFS nesting structure. Under the nested fuel structure of the RFS shown in Figure 1, D4 RINs can be used to satisfy the biomass-based diesel requirement, the total advanced requirement, or the total renewable requirement; D5 RINs can be used to satisfy either the total advanced or total renewable requirement; and D6 RINs can only be used to satisfy the total renewable requirement. This nesting structure implies that a D4 RIN is at least as valuable as a D5 RIN, and a D5 RIN is at least as valuable as a D6 RIN. Moreover, as a result of this nesting structure there are different RIN price "regimes," depending on which of the different requirements are binding, that is, which fuels if any are produced in excess of their requirement to generate RINs to satisfy an obligation within which it is nested.

To make this concrete, consider the example of Figure

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6 in which there are only two fuels, biodiesel and corn ethanol, and two RINs, D4 and D6. If the biodiesel subsidy value is less than the ethanol subsidy value, then biodiesel producers can produce in excess of the biodiesel requirement and sell the resulting D4 RINs for the purpose of satisfying the total renewable (conventional fuel) mandate. In this scenario, the amount of biodiesel produced will rise, and the amount of conventional ethanol will fall, to the point that the subsidy values in the two markets are equalized, so the D4 and D6 RINs have the same price. In contrast, if the subsidy value for biodiesel at the biodiesel requirement exceeds the subsidy value for conventional ethanol at its requirement, then biodiesel producers will have no incentive to produce excess biodiesel and the price of the D4 RIN will exceed the price of the D6 RIN.

More generally, the nesting structure implies the price inequalities, $P_{D4} \geq P_{D5} \geq P_{D6} \geq 0$ (where P_{D4} is the price of the D4 RIN, etc.). If the inequality is strict, then the mandate is binding, for example if $P_{D4} > P_{D5}$ then no biodiesel is being produced in excess of the biomass-based diesel mandate. In contrast, if $P_{D4} = P_{D5} = P_{D6}$, then both biodiesel and nondiesel, noncellulosic advanced fuels are being produced in excess of their mandates, and one or the other or both fuels are being used to generate RINs to satisfy the total renewable obligation [28]

Bankability implies that current RIN prices incorporate future subsidy values and policy expectations. Suppose that the requirement is low this year but is expected to rise next year, so the subsidy value needed to meet the requirements will rise. Because RINs are bankable, their price will rise above this year's subsidy value in anticipation of next year's stiffer requirement, inducing production in excess of the requirement this year. The excess RINs are banked and used next year. In this example, bankability increases RIN prices this year and lowers them next year. Because RINs can, in effect, be rolled over indefinitely (subject to the 20% rollover cap), this logic further extends to future years. Thus RIN prices today reflect market participants' views about the stream of subsidy values extending for the life of the program.

RINs have features that are similar to financial options. First, they can be exercised (retired) for compliance this year or in the future. Second, they have a nonlinear payoff function: the fundamental value of the RINs is positive if the annual subsidy value is positive, otherwise it is zero (because RINs need never be retired, their price cannot be negative). This latter feature is analogous to a financial option having exercise value only if it is in the money.[29]

Like a financial option, the price of RINs today will increase if there is an increase in uncertainty about future fundamental (subsidy) values. This uncertainty arises from uncertainty both about future economic fundamentals (weather, driving demand, oil prices, geopolitical factors) and about future policy. For example, suppose a multiyear policy path is announced with low RVOs. Because legal uncertainty and the annual rulemaking process make it difficult to commit convincingly to such a path, there will remain a chance that policy might return to the more expansive path of the statutory RVOs, and as a result there is a chance that the annual subsidy value will be high in the future. This possibility of high future RIN prices in turn adds in a premium (which could variously be called a risk premium, or time value, or option value) arising solely from uncertainty. Thus RIN prices depend both on expectations of future policy and on the degree of certainty about future policy.

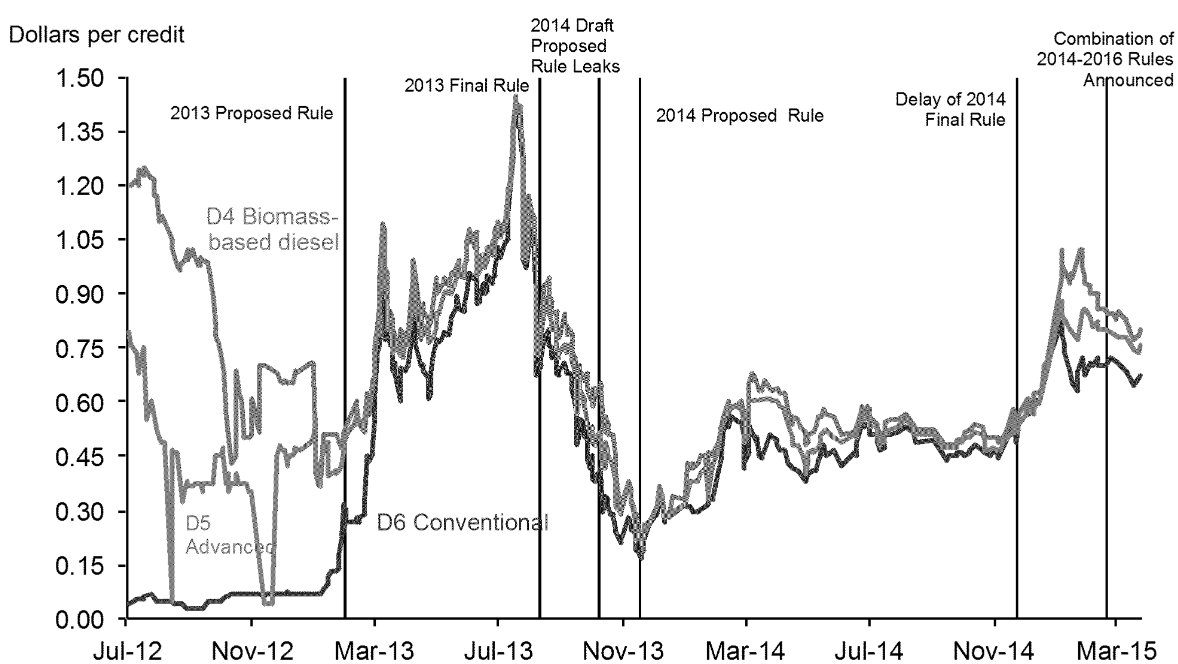
RIN PRICES SINCE 2012

Figure 7 shows the daily price of D4 (BBD), D5 (advanced), and D6 (conventional) RINs from July 2012 through March 24, 2015. Through the end of 2012, D6 RIN prices were low (less than $0.10) and the three RINs had distinct prices, indicating that the BBD, total advanced, and total renewable mandates were each binding. With increasing market awareness of the blend wall and with the release of the 2013 proposed rule, D6 RIN prices rose from mid-January through February 2013, and fluctuated around $0.75 from March through mid-May 2013. At this point, D6 RIN prices exceeded the 2012 D5 and D4 RIN prices, the BBD and Total Advanced RVOs became nonbinding—incentives were created to produce more advanced renewables—and excess D4 and D5 RINs were generated for compliance with the D6 mandate. Indeed, for most of the period since February 2013, the three RIN prices have moved in tandem, with the D4-D5 and D5-D6 spreads averaging $0.03 and $0.06, respectively, from March 2013 through November 30, 2014. These spreads arguably represent the greater option value associated with the lower RIN numbers: the option value for a D4 biomass-based diesel RIN will exceed that for a D5 RIN if there is some probability that the BBD RVO will be binding in the future (at which point the biomass-based diesel subsidy value will rise above the advanced fuel subsidy value). RIN prices separated again in early 2015 as petroleum prices fell.

Even though supply and demand conditions were relatively stable through 2013, with crop production recovering from the 2012 drought and the US and global economic growth relatively stable, 2013 saw large fluctuations in RIN prices. The initial run-up in RIN prices in early 2013 was due in part to the increasing awareness of the E10 blend wall, and some of the short-term volatility could have been due to the markets being thin.[30] The major source of the fluctuations, however, was arguably changing market expectations about the future course of policy.[31] RIN prices rose after the release of the 2013 proposed rule, which acknowledged the blend wall but indicated that there would be no adjustments to the total renewable or total advanced statutory RVOs, and that additional gaps between the RVO and the blend wall could be met by drawing down RIN stocks.

RIN prices fell substantially after the release of the 2013 Final Rule, which gave forward guidance indicating that, unlike the 2013 rule, the 2014 rule would be set bearing in mind the constraints of the blend wall. RIN prices fell further upon the leaking of a draft of the 2014 proposed rule, which proposed to use both the cellulosic and general waiver authorities to implement this guidance by backing the RVOs out of estimates of the total amount of ethanol that could be introduced into the fuel supply; the 2014 proposed rule implied 10.09% ethanol content, just over the E10 blend wall after taking into account a small amount of E85 sales. RIN prices rose subsequently based on evolving perceptions of the various pressures facing the EPA, including public statements that the RVOs could increase from the proposed to final 2014 rule and, most recently, the announcement that the 2014 RVOs would be finalized in 2015.[32]

Figure 7: Daily RIN prices, July 1, 2012 - March 24, 2015



Source: Bloomberg.

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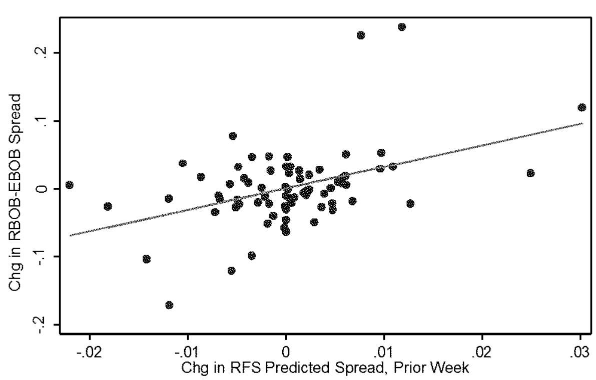
EFFECTS OF RIN PRICES ON FUEL PRICES

A central, highly charged question surrounding the RFS is the effect of RIN prices on pump prices.[33] In brief, RINs act as a tax on fuels with low renewable content and a subsidy to fuels with a high renewable content. As illustrated in Figure 6, in the long run (in equilibrium) the RIN price serves both to increase the supply of biofuels, relative to petroleum, and to increase consumption, and a RIN price increase is passed along in part to producers, who produce more, and in part to consumers. Because much of the debate has focused on the short-run link between RIN prices and fuel prices, the discussion here focuses on the short run, over which supply does not change and RIN prices change not because of current supply and demand considerations but for some other reason, such as changes in policy expectations.

To be concrete, consider RIN obligations in 2013, when the required RIN bundle consisted of a total of 0.0974 RINs (the sum of the required D3, D4, D5, and D6 RINs). Suppose all RIN prices increase by $1, so that the price of a RIN bundle increases by $0.0974. Because E10 is 90% petroleum, selling 0.9 gallons of petroleum would increase RIN costs to the obligated party by the cost of 0.9 RIN bundles, that is, by 0.9 x $0.0974 = $0.088. But blending 0.1 gallon of ethanol into E10 generates 0.1 D6 RIN, which the blender can sell for $0.10. In a competitive market, the petroleum producer passes on the $0.088 extra cost, the blender (who gets to sell the RIN) passes on the $0.10 savings, and the consumer comes out ahead by $0.012. Repeating the calculations above for diesel (which has a low renewable content) indicates that a $1 increase in the price of all RINs results in approximately a $0.05 increase in the price of diesel per gallon under perfect competition. Repeating the calculations again for E85 (which has on average 74% ethanol) results in a predicted decrease in the E85 price of $0.72 per gallon. Thus, with competitive markets and complete RIN price pass-through, if all RIN prices are $1, the net effect is a small subsidy to E10, a large subsidy to E85, and a tax on diesel, which has the lowest renewable content. The specific values of the tax and subsidy depend on RIN prices. For example, in mid-February 2015, D6, D5, and D4 RIN prices were approximately $0.70, $0.80, and $0.85, respectively; at those prices, with perfect pass-through their theoretical effect was to increase the pump diesel price by $0.03 per gallon, to decrease the E10 price by $0.01, and to decrease the E85 price by $0.50. Although specific tax and subsidy values depend on the RIN prices and the obligation percentages, the structure has the effect of taxing the lowest-renewable final fuel (diesel) and subsidizing the highest-renewable fuel (E85), with E10 receiving a slight subsidy because it has slightly more renewable content than the 2013 total renewable fractional obligation.

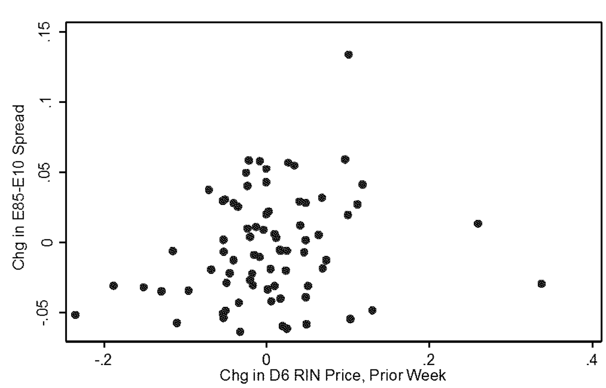
Figure 8 provides empirical evidence on two of these short-run pass-through predictions, for wholesale gasoline and for E10. On the margin, a refiner could choose to sell a gallon of gasoline into the US market, where the refiner

Figure 8a: RBOB-EBOB spread v. prior week RFS-predicted *(Weekly Changes, 01 Mar 2013 to 14 Aug 2014)*



Source: Bloomberg; author's calcula7ons

Figure 8b: E10 price v. prior week D6 RIN price



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would incur the RIN bundle cost, or export it. As such, in equilibrium, the wholesale price of gasoline in the United States (RBOB) should equal the international price, plus the per-gallon price of the RIN bundle, differential transportation costs, and other tax and fee differentials. To the extent that transportation costs and other taxes and fees either do not change, or have changes that are unrelated to changes in RIN prices, exogenous changes in the price of the RIN bundle should translate one-for-one into changes in the spread between RBOB and international wholesale gasoline prices.

This pass-through prediction is examined in Figure 8a, which plots the weekly change in the spread between RBOB (f.o.b. New York) and EBOB (f.o.b. Rotterdam) versus the previous week's change in the price of the RIN price bundle. The scatterplot shows that, on average, changes in RIN prices in the previous week are positively associated with changes in the RBOB-EBOB spread. Once lags are taken into account, the empirically estimated pass-through is consistent statistically with complete pass-through, which is to say, US wholesale prices generally rise when RIN costs increase, and fall when they decline.

Figure 8b examines the relation between changes in the E10 pump price changes in the D6 RIN price in the previous week. Consistent with the theory outlined above, there is negligible estimated effect of RIN prices on pump E10 prices.[34]

Figure 8c: E85-E10 spread v. prior week RFS-predicted *(Weekly Changes, 01 Mar 2013 to 14 Aug 2014)*

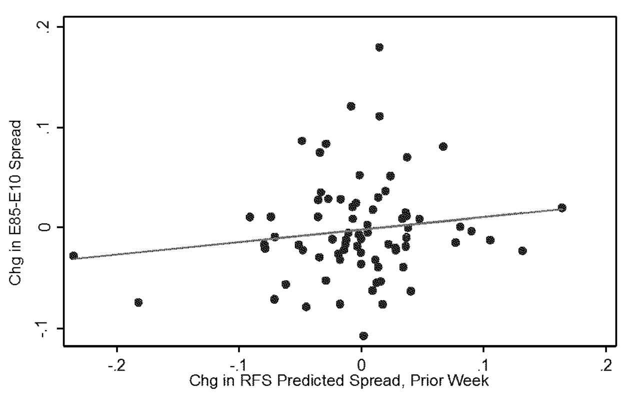

Figure 8c shows the relation between the change in the spread between E85 and E10 average retail prices and the predicted change in the spread based from previous-week changes in RIN prices. Consistent with theory, the relationship is positive (when the E85 price is predicted to drop, relative to E10, it does on average); however, the estimated pass-through is less than one-for-one. Regression analysis that includes lagged effects suggests that of a $1 increase in RIN prices, roughly one-third is passed through to consumers in the form of lower E85 pump prices. This finding of incomplete pass-through is consistent with the AJW Inc's (2013) finding of limited E85 price discounting, especially among major-brand stations, during the period of high RIN prices of 2013-2014.[35]

IMPLICATIONS FOR RFS POLICY

The overarching economic reason for the RFS and biofuels policy generally is to address four market failures, or externalities, in the market for biofuels. In this light, the role of the taxes and subsidies in the RIN system are to correct for existing market failures and to provide corrective subsidies to low-GHG domestic biofuels.

The first market failure is that carbon emissions impose a cost on future generations, but carbon is not priced in the market; in economic jargon, carbon emissions generate an externality, and the first-best policy would be to price carbon emissions to internalize that externality.

The second market failure is that fuel prices do not reflect externalities associated with energy security. This externality encompasses macroeconomic vulnerability to foreign oil supply price shocks and international policy costs borne by the United States as a result of its dependence on imported oil. In principle, if this externality could be monetized, then the first-best policy (putting aside legal considerations) would also be a tax to internalize this externality.

The third market failure is that the economic benefits of basic research and, to a lesser extent, learning by doing through early commercialization cannot be fully captured by private entities, so that the private sector will underinvest in basic research. This externality is relevant to biofuels because of its long lags between research and commercialization and the many biofuel pathways that are technically possible; first-best policy solutions provide cost-effective and reliable subsidies for early-stage research that incentivize ultimate wide-scale adoption of low-cost, low-GHG biofuels.

The fourth market failure is the presence of network externalities—that is, externalities that arise when the value to the user depends on the number of other users. In general network externalities can result in multiple equilibria that arise from "chicken and egg" problems, and these different equilibria can have values to society. These network externalities apply to biofuels that are not drop-ins, in particular to E85 sales of ethanol: if there are few E85 stations, the E85 market will not be competitive and each individual has little incentive to purchase (or utilize) a flex-fuel vehicle. Network externalities justify a government intervention when one of the equilibria produces greater social value than the other.[36]

These market failures and first-best policies, combined with the discussion of the previous section, highlight ten features of the RFS that are particularly salient for considering policy reforms.

1. The RFS cannot implement a first-best pricing policy because it is revenue neutral: it can adjust relative fuel prices based on their renewable content, but not overall fuel prices.

2. This said, in principle the RFS is capable of providing relative pricing incentives that capture the differential climate and energy security externality costs of the fuels in the various RFS fuel categories. The GHG externality value can be computed by using the US Government's Social Cost of Carbon, which is \$42 per ton of CO_2 in 2015 dollars[37] and by using ranges of GHG emissions consistent with various estimates of those in the different RFS fuel categories. The resulting range of externality values, on a RIN-gallon basis, is \$0.05–\$0.08 for D6, \$0.12–\$0.17 for D5, \$0.13–\$0.22 for D4, and \$0.15–\$0.21 for D3. [38] In the RFS Regulatory Impact Analysis, EPA estimated the energy security externality to be \$6.56 per barrel of renewable fuel (2007\$), with a range of \$0.94–\$12.23; this estimate translates into \$0.18 per ethanol-RIN gallon in 2015 dollars.[39] Combining the GHG externality with EPA's estimate of the energy security externality yields steady-state externality based RIN prices of roughly \$0.22–\$0.26, \$0.30–\$0.35, \$0.25–\$0.33, and \$0.33–\$0.39 for D6, D5, D4, and D3 RINs. There is considerable uncertainty around these ranges arising from, among other things, uncertainty about the life-cycle GHG reductions of the different fuels, the value of the social cost of carbon, and the energy security externality value,

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so these externality-based RIN prices are a rough guide only.

3. The relevance of the R&D externality varies greatly by fuel. The corn ethanol and biodiesel industries are mature, so for those industries the externality is reasonably set to zero. In contrast, some advanced drop-ins and all cellulosic fuels (with the possible exception of biogas) are in the nascent stages that justify additional research and development. Qualitatively, these considerations would justify spreads of D3 over D5 RINs, and of D5 RINs over D6 RINs, larger than those based on the steady-state externality values computed above. For the D3-D5 spread to be positive, the cellulosic RVO must bind, and for the D5-D6 spread to be positive, the total advanced RVO must bind. In addition, for the D4-D5 spread to be (approximately) zero, the BBD RVO must not bind.

4. Using the RFS to internalize externalities by achieving price targets confronts the challenge of the E10 blend wall.[39] With current low E85 penetration and awareness, small changes in quantities at or just above the blend wall currently result in large changes in RIN price fundamentals (Figure 6b).

5. In addition, bankability means that RIN prices reflect expectations not just of future supply and demand fundamentals but also of future policy decisions. Because policy uncertainty raises the time value, and thus the price, of RINs, and because the welfare and compliance costs of the RFS are mediated through RINs, policy uncertainty directly increases the welfare cost of the RFS program.

6. The ability of high RIN prices to stimulate biofuels investment depends on whether investors can count on a RIN price subsidy to continue into the future. A robust finding of the economic theory of investment under uncertainty is that, all else equal, uncertainty reduces irreversible investment because firms prefer to wait until the uncertainty is resolved (e.g. Bernanke [1983], Majd and Pindyck [1987]). Thus policy uncertainty produces high RIN prices, but that uncertainty undercuts the ability of those high RIN prices to stimulate investment and the associated private R&D.

7. Because the total renewable pool is dominated by the conventional pool, the largest component of overall program compliance costs is the D6 RIN price, which in turn is driven by the blend wall and expectations (and uncertainty) about future policy concerning the blend wall.

8. Making commitments within the RFS is challenging because of the annual nature of the rulemaking under the EISA, combined with political pressures from stakeholders.

9. The RFS has so far been ineffective in stimulating sales of higher blends. There appears to be incomplete pass-through of RIN subsidies to E85 prices, and there has been slow national growth of E85 sales in 2013 and 2014 despite high RIN prices. A plausible working hypothesis is that slow growth of E85 sales stems from a combination of policy uncertainty (so that high RIN prices cannot be counted on over the period needed to pay off the fixed costs of blender pumps or tank upgrades), a lack of competition in the E85 market (because of the limited number of E85 service stations), and a group of consumers who are willing to pay a premium for E85. If so, as long as these conditions persist, the RFS will continue to be an inefficient and ineffective program for increasing sales of higher blends.

10. Two features of the RFS further impede its ability to provide support to cellulosic biofuels beyond that provided to advanced biofuels: the statutory cap on what EPA can charge for cellulosic waiver credits (set by EPA to be $0.42 in 2013), which in

turn caps the spread between the D3 and D5 RINs, and the 2013 court ruling requiring EPA to set the cellulosic RVO using a "neutral methodology" aimed at providing a prediction of "what will actually happen" regarding cellulosic production in the compliance year. If a neutral estimate is interpreted as meaning median-unbiased,[40] then half of the time the estimated cellulosic RVO would be less than actual production, that is, half the time the cellulosic RVO would not be binding. If so, the D3-D5 spread would be positive only because it might bind in a future compliance period. The first of these features caps the additional RIN price support that the RFS can provide to cellulosic production, and the second of these features pushes that additional support to zero, possibly strongly so. Because 2014 will be the first year with nonnegligible cellulosic production there is no historical experience yet on the impact of these twin restrictions on D3 RIN prices.

THREE POSSIBLE PATHS FOR BIOFUELS POLICY AND THE RFS

The introduction laid out three paths forward for the RFS and biofuels policy: a flexible, status quo path of making annual rulemakings as circumstances and policy goals evolve; a conservative path in which EPA commits to staying within the blend wall while supporting advanced biofuels; and an ambitious path for expanding both conventional and advanced biofuels. This section fleshes out and analyzes these three paths in light of the foregoing discussion of the economics of the RFS.

The context for this evaluation is the broader biofuels policy goal of promoting, in an economically efficient way, low-GHG domestic advanced biofuels and enhancing macroeconomic energy security. The transportation sector remains a particularly challenging area for achieving a transition to a low-carbon future. While there are advanced technologies for substantially reducing GHG emissions in transportation, such as hydrogen fuel cells and electric vehicles powered by renewables, they remain expensive and confront major technological and infrastructure hurdles. For these reasons, and because of their energy density and convenience, liquid fuels will plausibly continue to play an important role in the transportation sector in the foreseeable future. Although infrastructure changes or upgrades are needed for widespread use of advanced low-GHG biofuels in the transportation fleet, those changes are relatively modest compared with alternative low-GHG technologies. In this view, advanced biofuels act as a bridge to the zero-carbon technologies of the future.

The focus in this section is on these three paths for the RFS. The next section turns to specific reforms within the existing RFS, steps that can be taken outside the RFS, and possible legislative reforms to the RFS.

The first two paths each have advantages. The first path, which entails annual rulemaking with limited forward guidance, allows the EPA maximum flexibility as biofuels policy evolves. The second path, committing to a conservative approach to the blend wall, holds the promise of low D6 RIN prices and low compliance costs. But both paths have disadvantages. The first path, with its annual focus, invites a continuation of the policy uncertainty and RIN price volatility experienced since early 2013, resulting in the undesirable combination of high compliance costs and low investment both in nascent low-GHG technologies and in the E85 infrastructure investments that could relieve the pressure of the E10 blend wall. If credible multiyear commitment to a conservative path were possible, the second path would address the problem of uncertainty and high compliance costs, albeit not necessarily providing additional support to advanced biofuels.[42] But it is unclear whether EPA can make a credible multiyear commitment to a conservative path, and to the extent that there is a reasonable chance that the policy will be reversed in the future, the second plan, like the first, would entail policy uncertainty and the consequent combination of moderate to high compliance costs and low investment. Thus both these paths are unlikely to achieve the policy goal of economically efficient support for the development and potential widespread adoption of low-GHG domestic biofuels.

The third path—an ambitious expansion of both total renewable and advanced biofuels—could be implemented in various ways. For concreteness, the discussion here will focus on one specific implementation path, which relies on the cellulosic but not general waiver authority within the EISA. Specifically, this implementation would use the cellulosic waiver authority to reduce the total renewable RVOs by the amount of the cellulosic production shortfall, and to reduce the total advanced RVO by a lesser amount for a transitional period, after which the total advanced RVO would be reduced by the same amount as the total renewable RVO.[43] This combination of temporarily different reductions would result in a path for the growth of conventional biofuels that would ultimately hit the 15 Bgal statutory cap, but would do so later than the 2015 statutory date. Applying a smaller reduction to total advanced would recognize that the market is able to supply substantial quantities of advanced fuels, and would meet the policy objective of providing support for investment in new advanced and cellulosic technologies and production. The temporarily differential application

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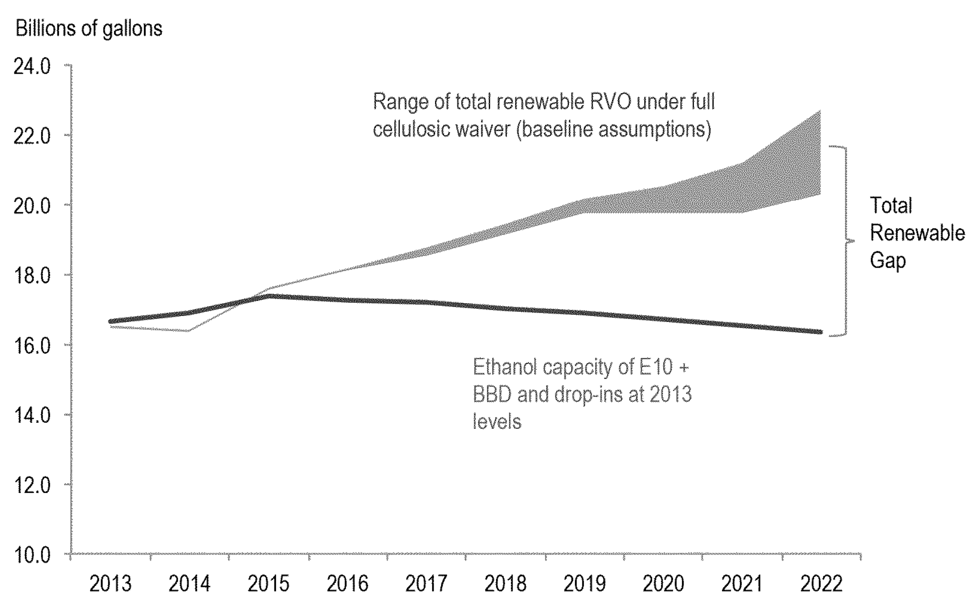
of the cellulosic waiver authority would initially ease the pressure of the blend wall while committing to a policy path to expand consumption of conventional ethanol, which would in turn provide the multiyear support needed for investment in E85 infrastructure.

The challenge for this path is that the incremental volume of renewable fuels required is large. Moreover, even though the conventional fuel component is capped at 15 Bgal under the statute, the statute calls for increasing volumes of noncellulosic, non-BBD advanced biofuels; thus, even using the full cellulosic waiver authority, the total renewable RVO would increase. Because EIA projects flat then declining total gasoline consumption, under this path conventional biofuels would constitute an increasing share of fuel consumption, even as the capacity for ethanol sales through E10 is flat or declining. These dynamics thus create an increasing "total renewable gap" between the total renewable RVO and what can, or has been, supplied within the E10 blend wall.

Figure 9 illustrates a range of plausible magnitudes for the total renewable gap, which is the difference between the total renewable RVO under the full cellulosic waiver and the sum of the amount of ethanol in E10, the volume of nonethanol fuels supplied in 2014, and projected growth of cellulosic fuels. E10 capacity is projected based on EIA projections.[44] Said differently, Figure 9 shows the D6 RIN shortfall that would have occurred in 2014 (when nearly all ethanol was sold as E10), had the total renewable RVO been set at the level implied by the cellulosic waiver reduction in the various years plotted, adjusted for EIA's projected decline in total gasoline demand. The range of the shortfall shown in Figure 9 is illustrative and reflects two sources of uncertainty: uncertainty about future gasoline consumption and uncertainty about the growth of cellulosic biofuels.[45]

Figure 9: The total renewable gap under the cellulosic waiver



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The shortfall illustrated in Figure 9 can be filled by any RIN-generating biofuel because all renewable fuels produced in excess of their RVO can be used to meet the total renewable RVO. In practice, the shortfall would most likely be filled by some combination of increased domestic biomass-based diesel produced in excess of the BBD RVO, increased conventional BBD imports, and increased sales of higher ethanol blends. These higher ethanol blends could be E15, E85 or, in theory, an intermediate blend. Some ethanol advocates promote E15 as an attractive high-octane fuel, however its penetration to date has been very low and there is controversy surrounding the E15 capability of many of vehicles on the road today. In contrast, E85 is a small but established fuel, and because of its high ethanol content far fewer gallons of E85 than E15 need to be sold to fill the total renewable gap. For these reasons, the discussion here about higher ethanol blends focuses on E85.[46]

Figure 10a shows the range of volumes of domestic BBD (in wet gallons) that would be needed were the total renewable gap to be filled entirely with D4 BBD. In 2013, 1.8 Bgal of domestic BBD was produced, and initial estimates based on 2014 D4 RIN generation point to a similar volume produced in 2014. Under the ranges in Figure 10a, these volumes increase to 1.9–2.4 Bgal in 2015 and to 2.7–3.2 Bgal in 2017, climbing by 2022 to 4.4–5.7 Bgal. Because the existing literature on the supply curve (both static and dynamic) for biodiesel is quite limited, it is difficult to estimate accurately what the economic effects of these increases would be, but the available evidence suggests that these represent very large increases in biodiesel over historical levels and even in the short run imply large to very large annual subsidy values.[47] In the long run, meeting these increases with domestic biodiesel would require doubling or even tripling domestic industry capacity and would have impacts on feedstock prices that are hard to predict but would very likely be substantial.[48] Although the United States currently imports some biodiesel, those imports would need to expand tremendously. The volumes in Figure 10a are so large after 2016 that it is unrealistic to think they will be filled entirely by domestic biodiesel, and instead that much or all of these increases need to come from E85, for which the increase in marginal cost of production associated with this expansion is much less than for BBD.

Figure 10: Filling the total renewable gap

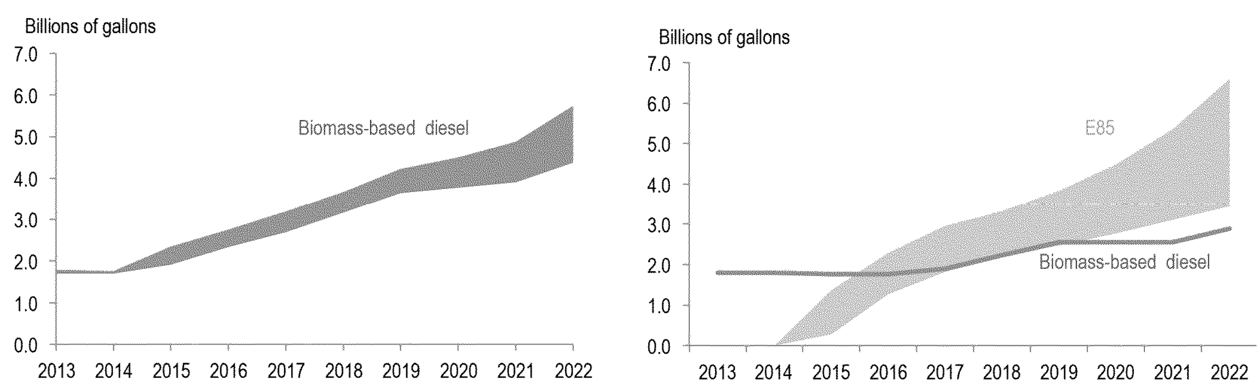

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Figure 10b considers the alternative scenario in which E85 expands to fill the gap in conventional biofuels.[49] The total renewable gap is the sum of a total advanced shortfall and a shortfall in the conventional pool. In the cases considered in Figures 9 and 10, there is no significant shortfall in total advanced until 2018, after which the advanced shortfall rises to 1.7 Bgal (RIN gallons) in 2022. In Figure 10b, it is assumed that this advanced shortfall would be filled by BBD. Figure 10b also shows the volume of E85 needed to fill the remaining gap in the conventional pool. Under the cases in the figure, this volume is 1.3–2.3 Bgal in 2016, rising to 3.4–6.6 Bgal by 2022. Although there is technically the flex-fuel vehicle capacity to consume these quantities, doing so would require a vast increase in E85 sales. By 2022, the range in Figure 10b requires that the average ethanol content of US fuel supply be approximately 11.7–13.4%. To date, E85 has been lackluster, except perhaps in the few states that have had significant programs to promote E85 stations.[50]

The discussion of Figures 9 and 10 has so far omitted two factors that could postpone the opening of the large total renewable gap in Figure 9: increasing imports of nonethanol fuels, and increased gasoline consumption because of low oil prices.

Two recent developments suggest that imported biodiesel and renewable diesel could fill at least part of the total renewable gap. First, in 2013 conventional BBD generated approximately 250 million D6 RINs, and in 2014 this figure rose to approximately 340 million D6 RINs, up from less than 10 million D6 RINs in 2011 and 2012. This increase appears to be associated with conventional biodiesel imports. Although more needs to be known about the supply capacity for imported conventional biodiesel and renewable diesel, there is a possibility that these imports could expand further. Second, in January 2017 EPA approved a streamlined tracking program for Argentinian soy biodiesel, which the National Biodiesel Board estimates could potentially introduce 0.6 Bgal of BBD annually that would generate D4 RINs.[51] Although the net effect of these imports on RIN prices under the scenarios in Figures 9 and 10 is unclear, the potential for increasing volumes suggests that the total renewable gap in 2015 and possibly 2016 could be filled with imported biodiesel, and if so D4, D5, and D6 RIN prices would continue to be equal. Imported biofuels are consistent with the GHG reduction goals of the EISA (assuming their pathways are accurately assessed) but, from a macroeconomic energy security perspective, have similar effects to oil imports. In any event, a real possibility, at least in the short run, is that the total renewable gap would be met with nonethanol biofuel imports.[52]

The second factor is the sharp decline in oil prices since June 2014. Figures 9 and 10 use the February 2015 STEO projections for 2015–2016, with gasoline demand growth rates from the AEO 2014 thereafter. The February 2015 STEO forecast for 2015 is up 2.4% from the 2015 forecast made in May 2014 (9.00 million b/d, up from 8.79 million b/d). However, historical evidence on gasoline supply elasticities suggests that the cumulative increase in gasoline demand, relative to June 2014 levels, could be 8%, a much greater increase than EIA forecasts.[53] To illustrate the importance of this potential increase in gasoline demand, beyond the baseline used in Figures 9 and 10, Figure 11 shows the total renewable gap if gasoline consumption exceeds the February 2014 STEO by 4% (so the total increase is 6.4%, relative to June 2015 levels). Under this high gasoline demand scenario, the total renewable gap is substantially less through 2017, with a range of essentially no gap to 0.9 Bgal in 2017, a gap that could plausibly be filled by modest domestic expansion of E85 sales combined with increased biodiesel and renewable diesel imports as discussed above. The gap expands post-2017; however, under this scenario, higher gasoline demand combined with nonethanol imports provides a window to prepare for this expansion.

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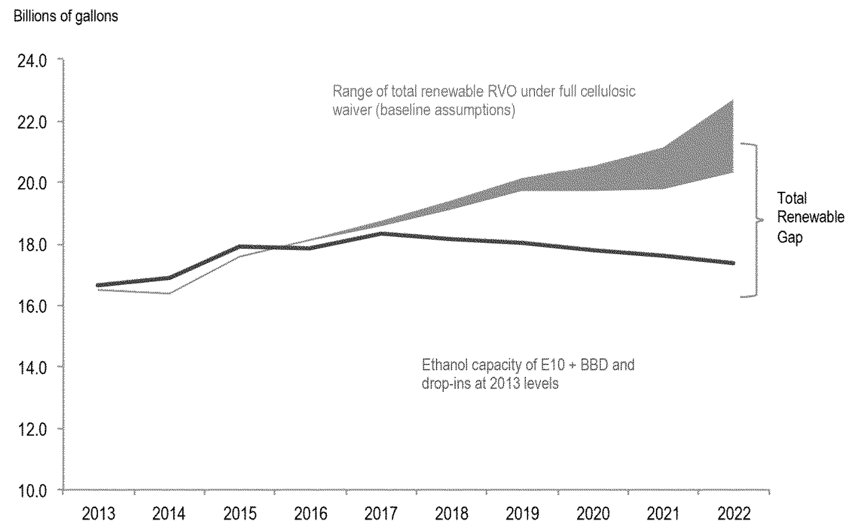
Figure 11: The total renewable gap under cellulosic waiver, high gasoline demand scenario



In the high gasoline demand scenario, gasoline consumption exceeds EIA projections by 4% to reflect potential additional growth in demand in response to low gasoline prices. See the notes to Figure 9. Source: Author's calculations

The discussion so far does not address the requirement in the EISA that EPA reset the volumes if it waives that volume by 20% for two consecutive years, or by 50% for one year, but no earlier than in 2016. Little has been written on this provision, but a straightforward reading of the EISA suggests that these reset triggers and requirements apply separately to the different RVOs. The cellulosic trigger has already been reached, so its volumes will need to be reset in 2016. Under all scenarios here, the total advanced trigger is hit in 2016, requiring a reset in 2017, and the total renewable trigger is hit in 2018, requiring a reset in 2019. These resets could reduce the RVOs, but under the cellulosic waiver path laid out in Figure 9, the total renewable gap would be 2.1–2.9 Bgal (RIN gal) in 2018, corresponding in Figure 10b to 2.1–3.3 Bgal of E85 sales. Even though the very large volumes of E85 after 2020 could be avoided by a conservative reset, the path to reach the 2018 reset considered here would require a breakthrough in E85 sales.

In summary, this discussion of Figures 9–11 yields four main conclusions. First, under the ambitious path using only the cellulosic waiver authority, very significant expansions would be necessary in biofuels. Second, although some of the gap could be filled by BBD, at least in the short run, it would be prohibitively expensive if not impossible to fill much or even most of the gap by BBD. Third, this expansion path provides considerable opportunities for BBD to be produced with high RIN prices, even if only to meet the total advanced RVO (as in Figure 10b), so there is no need for further supporting BBD through expanding the BBD RVO. Fourth, the alternative, expansion of ethanol consumption, would require massive increases in E85 sales. Based on fundamentals, increasing E85 sales could be cost effective—far more so than increasing BBD sales—but doing so requires moving the blend wall.

The challenge, then, is how to move the blend wall over the next few years to enable this expansion and to contain RFS compliance costs. If this ambitious path is in fact able to spur additional sales, then overall program economic costs can be kept down, including separating the D5 and D6 RIN prices as had been the case until early 2013. The history of the RFS and ethanol consumption suggests that the RFS alone is inadequate for spurring additional E85 sales; rather, the few states that have substantial sales have achieved those by complementary programs.[54] For this path to be viable and credible, a commitment to this path therefore needs to be coupled with a wide-ranging program to spur substantial additional ethanol sales.

BEYOND THE 2014 RULE

This section outlines several policy reforms that could provide more effective support for advanced, low-GHG, domestically produced biofuels. The section starts with modest but meaningful initiatives and reforms that can be undertaken within the existing RFS framework, then turns to reforms that would entail congressional action. This list is both incomplete and terse, and additional analysis of these and other proposals remains.

POTENTIAL REFORMS WITHIN THE RFS FRAMEWORK

Multiyear guidance and a multiyear plan. Even within the current annual rulemaking requirements of the RFS, EPA can reduce uncertainty by announcing a multiyear plan with transparent formulas. The previous section argues that, to be consistent with the goal of providing economically efficient support for the development and potential widespread adoption of low-GHG domestic biofuels, the announced path should be both ambitious and credible. Achieving credibility requires committing to a path in the future. EPA's announcement on February 19, 2015, that it would issue the 2014, 2015, and 2016 rules together is a meaningful step toward providing multiyear plans.

Forward guidance could be provided by EPA announcing a methodology (formulas) going forward along with a legal strategy to support that methodology. Were EPA to adopt the third path proposal laid out in the previous section, EPA could reduce uncertainty by announcing that it intends to use only the cellulosic waiver authority; it could find that it is consistent with the environmental policy intent of the statute that the cellulosic waiver authority be applied in full to reduce the total renewable obligation but to reduce the total advanced obligation by a lesser amount and use that differential authority from the outset; it could find that the demonstrated ability of BBD to compete with other advanced fuels in the advanced pool, and indeed in the conventional pool, combined with estimates of high marginal costs of supplying biodiesel, would justify no further expansion in the BBD RVO; and it could provide clarifying forward guidance on what market conditions would lead it to invoke the general waiver authority, both weakening its discretion and providing a clearly delineated safety net. Credibility would be further enhanced by providing precise, clearly articulated goals that both recognize the challenges ahead and outline complementary actions that will help to achieve that path in an economically efficient way.

Work to expand E85 consumption beyond simply relying on high D6 RIN prices. Examples of such initiatives include:

- ***Work to Improve Transparency of E85 Pricing.*** The ethanol content of E85 can range from 51–83% ethanol. This large range accommodates regional and seasonal variation including vapor pressure regulations and cold start conditions. But a consumer who does not know the precise ethanol (and thus energy) content of the fuel cannot comparison shop between E10 and E85, indeed she cannot even shop between different stations carrying E85. A conceptually straightforward fix to this problem would be to post E85 prices on an E10-equivalent basis. For example, E85 that contains 65% ethanol has 82% the energy content of E10; if that E85 were selling for $2.00/gallon, its E10-equivalent price would be 2.00/.82 = $2.44/gallon—which the consumer could then recognize as a bargain if E10 is $2.80/gallon. This approach could be refined to account for ethanol octane boosting, but the point is to provide a simple, transparent way to encourage flex-fuel vehicle owners to comparison shop. The resulting transparency would also encourage price competition and RIN pass-through to E85.

- ***Work to Improve E85 Penetration and Competition.*** As discussed above, one plausible factor in the lack of pass-through of RIN prices into E85 pump prices is the lack of local competition in E85 stations. Increasing the density of E85 outlets would both increase availability and support price competition among E85 stations, just as there is price competition in E10. Although the federal

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government has limited ability to support blender pump installations,[55] there still is opportunity to work with industry and to promote industry efforts to expand blender pump (and especially E85) penetration.

Expedite the pathways approval process. There has been a chronically long lag in approving new pathways (the combination of feedstocks, their sources, and the technology by which they are transformed to fuel) under the RFS (McCubbins and Enders [2013]). This long approval queue runs against the program goal of incentivizing new low-GHG advanced fuels and technologies. In March 2014, EPA announced an initiative to expedite the pathways approval process.[56] The success of these reforms will be contingent on having EPA resources to implement them and to work through the backlog, which could benefit from additional targeted administration and interagency efforts.

Consider changing the obligated parties. RINs are separated at blending but the obligated parties are refiners and importers, not blenders. This creates two frictions. First, because blenders either are retailers or sell to retailers, blenders are better situated to pass the RIN subsidy for high-renewable content fuels along to the consumer than are the current obligated parties, who are further upstream. This raises the possibility that shifting the obligation to the blenders could improve RIN pass-through in E85 and other higher blends. Second, some obligated parties, such as merchant refiners, are currently left with net RIN deficits that need to be filled on the market by purchasing RINs from net RIN generators. As discussed previously, movements in RIN prices appear to be passed through to RBOB prices, suggesting that obligated parties with net RIN deficits can pass through their RIN costs on average.[57] Still, the current system leaves those obligated parties with net exposure to RIN price fluctuations, and their ability to recover RIN costs might be incomplete because of lags and variability in RIN prices. The purpose of the RIN system is to ensure compliance with the RFS, not to add price risk to the balance sheets of obligated parties that happen to have a generation/obligation mismatch.[58]

REFORMS THAT LIKELY REQUIRE CONGRESSIONAL ACTION

RIN price collar. A theme of this analysis has been that the RFS introduces uncertainty in compliance costs and in cross-subsidies because it is a quantity-based regulation in a situation in which price-based regulation is arguably more appropriate. A RIN price collar—a floor and ceiling on RIN prices, with different collars for different RIN categories—addresses this defect. The floor would ensure a continued base level of subsidy for renewable fuels while the ceiling would provide a cap to compliance costs. Providing both a ceiling and a floor would provide certainty to parties involved with the RFS. The floor and ceiling could be based on various considerations including the externality costs of nonrenewable fuels (environmental and energy security), nascent industry arguments (which would support additional higher D5 and D3 RIN prices), and the policy goal of supporting domestic, low-GHG, second-generation advanced fuels.

Change RIN generation from energy-equivalent values to GHG-reduction values. For example, under this proposal a biofuel with a 60% life-cycle GHG reduction (relative to petroleum on a Btu basis) would generate three times as many RINs as a biofuel with a 20% GHG reduction. This could be done within the current four fuel categories in Figure 1, using the statutory reductions for the qualifying fuels; this simply entails establishing a conversion rate for the different categories of RINs based on category threshold GHG reduction (for example, a single D3 RIN could be exchanged for three D6 RINs which in turn could be used to satisfy the total renewable obligation). Alternatively, each fuel pathway could have its own RIN generation multiplier. As a practical matter, administering fuel- and pathway-specific RIN conversions could be administratively challenging and GHG life-cycle analysis is a source of considerable uncertainty, so category-wide RIN conversion schedules might be sufficient. Mechanics aside, this change would provide subsidies to fuels in proportion to their GHG reductions and would provide additional incentives for the expansion of low-GHG fuels. At an extreme, the markets for different RINs and the distinct RVOs by category could be replaced by a single RIN, a single total RIN-equivalent volumetric target (specified in terms of conventional RIN gallons), and a single RIN fractional obligation (instead of currently retiring a bundle of RINs for each gallon petroleum fuel). All biofuels would thus compete to generate the RINs necessary to meet that target. This proposal could be combined with a floor and ceiling on the (single) RIN price to provide certainty to all market parties.

Lengthen the time between RFS rulemakings. Longer rulemakings—for example, quadrennial instead of annual—would address several fundamental problems. Most importantly, a multiyear obligation would provide investors with more guidance on which to make their decisions. Switching to a multiyear rulemaking would require additional technical changes given that the RFS is currently specified in volumetric mandates but is operationalized in fractional standards. Because of the blend wall, multiyear rulemakings would need to be combined with clear policy toward the blend wall. The technical challenges of multiyear quantity and fractional rulemakings are mitigated if there is a RIN price collar, which would stabilize RIN prices in the event of unexpected supply and demand developments.

Increase support for cellulosic fuels. Direct support for cellulosic fuels is currently limited by the statutory RIN price cap and the court-mandated requirement for a "neutral" estimate of cellulosic production. There are several mechanisms to provide greater support than is possible given this determination. The most direct and straightforward would be to implement the 10-year cellulosic production tax credit (with phase-out in final years) in the President's 2015 budget. An alternative would be support through an investment tax credit for cellulosic demonstration and production facilities. Another alternative would be to raise the cap on the cellulosic waiver in the RFS, which is currently set statutorily and is indexed to gasoline prices. However, although the cellulosic waiver price is currently used to price a synthetic D3 RIN, it is unclear whether the cap would be binding in a robust cellulosic market given the mandated "neutral" estimate of cellulosic production.

Support higher fractions of flex-fuel vehicles. Because the most cost-effective pathway toward a zero-carbon transportation sector is currently unclear, biofuels policy should aim to preserve the option for biofuels being an important part of that transition or possibly part of the long-term low-carbon solution. The view suggests developing the option that the fuel supply be capable of absorbing large volumes of advanced and cellulosic ethanol, which would require a vehicle fleet able to handle high ethanol blends. Because of slow fleet turnover, keeping open this possibility on the ten-to-fifteen-year time horizon means increasing the fraction of flex-fuel vehicles produced. One option to consider would be adopting a flex-fuel (E85-capable) vehicle standard, while options short of such a standard include incentives for flex-fuel vehicles.

CONCLUSION

The goal of reducing US dependence on imported oil through low-carbon domestic alternatives remains as valid today as when the EISA was passed in 2007. Indeed, the sharp drop in oil prices since June 2014 makes the transition to a low-carbon transportation sector both more pressing and more challenging. At present there is no clear economically dominant technology among the multiple routes to a low-carbon transportation sector. The combination of GHG externalities, energy security considerations, and the spillover benefits of research and development therefore justify policies that support the development of a range of nascent alternatives to petroleum and thus keep technological options open. One such alternative is second generation biofuels, and because the Renewable Fuel Standard is the main tool of U.S. biofuels policy, the policy challenge facing the RFS is to provide support for domestic low-carbon advanced biofuels, while doing so as economically efficiently as possible.

This paper argues that the RFS can provide this support for domestic, low-GHG advanced fuels through adopting an expansive path for its volumetric obligations – increasing the amount of renewables in the fuel supply. But providing this support effectively and economically efficiently requires a combination of efforts and reforms both within and outside of the RFS. To support the necessary investment in production and distribution, the path must be credible and must reduce the uncertainty surrounding RFS policy. Over the next year or two, potential increases in non-ethanol biofuel imports combined with increased gasoline consumption spurred by low oil prices could ease the pressure of the E10 blend wall. Looking ahead, however, the key to making an expansive path economically efficient is to expand E85 consumption. While expansion of E85 will be encouraged in part by a credible RFS path, more is needed, including transparency of pricing and programs to support additional E85 dispensers. Absent replacing the RFS with a first-best alternative, legislative reforms should focus on making the RFS both more efficient economically and more effective in supporting advanced low-GHG domestic fuels, for example by enabling EPA to impose a price collar (both floor and ceiling) for RINs that reflects GHG externalities, energy security externalities, and nascent industry considerations.

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ENDNOTES

[1] See for example A. Rascoe, "UPDATE 1-Oil exec says ethanol RINs 'out of control', urges action," Reuters, 16 July 2013, http://www.reuters.com/article/2013/07/16/congress-gasoline-hearing-idUSL1N0FM0PP20130716; G. Morgenson and R. Gebeloff, "Wall St. Exploits Ethanol Credits, and Prices Spike," *New York Times*, 14 September 2013, http://www.nytimes.com/2013/09/15/business/wall-st-exploits-ethanol-credits-and-prices-spike.html?pagewanted=all&_r=0; D. Strumpf, "Lawmakers Examine Ethanol Credits' Affect on Gas Prices," *Wall Street Journal*, 14 March 2013, http://www.wsj.com/articles/SB10001424127887324532004578360341241306954; M. Parker, "Gasoline Price Inflatedby Ethanol in Oil Boom: Energy Markets," Bloomberg, 21 March 2013, http://www.bloomberg.com/news/articles/2013-03-21/gasoline-price-inflated-by-ethanol-in-oil-boom-energy-markets

[2] The preamble to the EISA reads in full: "To move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government, and for other purposes." (Public Law 110-140 at http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/content-detail.html) This preamble could be interpreted as supporting clean (low-greenhouse gas) biofuels is a purpose of the act or alternatively that supporting clean biofuels production is a means to an end, with the purposes of the act being energy security and cleaner fuels; I adopt the latter interpretation.

[3] The EISA sets out annual volumetric targets for four categories of renewable fuels, which vary by type and by life-cycle greenhouse gas emissions reductions relative to petroleum gasoline. Because the statute specifies volumes and gasoline consumption has been running 12% below 2007 projections, the statutory renewable requirements comprise a considerably larger fraction of the fuel supply than originally projected. EPA is required to convert these volumes into fractions of renewables per gallon through annual rulemakings that can exercise waiver authorities granted in the statute. The waiver authorities and annual rulemakings provide flexibility but also open the door to revising RFS policy annually.

[4] Environmental Protection Agency, "Renewable Fuels: Regulations & Standards," epa.gov/otaq/fuels/renewablefuels/regulations.htm.

[5] Net imports of oil and petroleum products averaged nearly 12.6 million barrels per day (b/d) in 2005. For the first 10 months of 2014, they averaged 5.1 million b/d. EIA, "US Net Imports of Crude Oil and Petroleum Products," http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mttntus2&f=m.

[6] The White House Council of Economic Advisers noted that factors reducing net oil imports and improving economic resilience to oil shocks included lower domestic petroleum demand, increased domestic oil production, more efficient vehicles, and increased use of biofuels. "The All-of-the-Above Energy Strategy as a Path to Sustainable Economic Growth," May 2014, http://www.whitehouse.gov/sites/default/files/docs/aota_energy_strategy_as_a_path_to_sustainable_economic_growth.pdf.

[7] E85 can contain between 51% and 83% ethanol. EIA assumes the average ethanol content of E85 is 74% (*Annual Energy Outlook* 2014, p. A-5, fn. 9).

[8] The dominant diesel standard currently is B5, which permits up to 5% biodiesel content. In 2013 biodiesel constituted approximately 3% of diesel fuel. Some engines can use higher blends, such as B20. Renewable (non-ester) diesel constitutes slightly less than 1% of diesel fuel. See EPA (2007) and the DOE Alternative Fuel Data Center at http://www.afdc.energy.gov/fuels/biodiesel_basics.html and http://www.afdc.energy.gov/fuels/emerging_green.html. Whether there is a biodiesel blend wall is a matter of debate (for the case against, see the National Biodiesel Board at http://www.biodiesel.org/docs/default-source/ffs-basics/biodiesel-blend-wall-myth-fact-sheet.pdf?sfvrsn=8). At the volumes under consideration in this paper, I assume there is no biodiesel blend wall.

[9] C. Krauss, "Dual Turning Point for Biofuels,"*New York Times*, April 14, 2014, http://www.nytimes.com/2014/04/15/business/energy-environment/dual-turning-point-for-biofuels.html?_r=0.

[10] 79 FR 42128.

[11] This list, and Figure 1, omits cellulosic diesel, which is its own separate regulatory category; however, no cellulosic diesel has yet been produced commercially.

[12] EPA has further argued that the statute requires that if EPA exercises the cellulosic waiver, it must do so by reducing the total renewable and total advanced standards by the same amount (74 FR 24914-15 and 78 FR 49810). EPA reasons that reducing the advanced standard by more than the conventional "would allow conventional biofuels to effectively be used to meet the standards that Congress specifically set for advanced biofuels" (78 FR 49810). Some commenters argued that reducing the total renewable standard by more than the advanced standard recognizes total biofuel shortfalls but achieves the environmental goals of the statute by allowing low-GHG advanced fuels to replace part of the shortfall in (low-GHG) cellulosic. Because EPA has not actually applied the cellulosic waiver authority to the total or advanced standard, this issue remains open in the sense that it has not been tested in the courts. This issue is potentially relevant for setting the 2014–2016 standards in a way that is consistent with the environmental goals of the statute and is returned to below.

[13] The statutory language for the two criteria allows waiving the statutory volumes either: (i) based on a determination by the administrator, after public notice and opportunity for comment, that implementation of the requirement would severely harm the economy or environment of a state, a region, or the United States; or (ii) based on a determination by the administrator, after public notice and opportunity for comment, that there is an inadequate domestic supply [42 USC §7545(o)(7)(A)].

[14] 42 USC §7545(o)(2)(B)(ii).

[15] *API* v. *EPA*, No. 12–1139, slip op. at 5–9 (D.C. Cir. January 25, 2013). The ruling vacated the 2012 cellulosic standard. See the discussion in the EPA 2013 final rule, 78 FR 49798 and 49800-49801.

[16] Schnepf and Yacobucci (2013).

[17] 42 USC §7545(o)(7)(F).

[18] The RFS obligations are stated in terms of cellulosic biofuels, advanced biomass-based diesel, total advanced, and total renewable (EPA 2013 RFS final rule, 78 FR 49826 [August 15, 2013], Table IV.B.3-2). The D5 RIN obligation is computed as the difference between the total advanced obligation and the sum of the advanced biomass-based diesel and cellulosic biofuel obligations, and the D6 RIN obligation is computed as the difference between the total renewable and total advanced obligation.

[19] A 2012 RIN can be sold in 2013 to satisfy a 2013 obligation, and a 2013 RIN can be purchased, effectively extending the 2012 RIN's lifetime for a year at the cost of the transaction.

[20] The EISA specifies that EPA make cellulosic credits available at a price which is the higher of $0.25/gallon or the amount by which $3.00 per gallon exceeds the average wholesale price of gasoline per gallon, adjusted for inflation (42 USC §7545(o)(7)(D); these cellulosic waiver credits, plus a D5 RIN, can be used to meet the cellulosic requirement (75 FR 14726-14728 and 78 FR 49826-49827).

[21] RBOB (reformulated blendstock for oxygenate blending) is petroleum motor gasoline intended for blending with oxygenates, such as ethanol, to produce finished reformulated motor gasoline, see eia.gov/dnav/pet/TblDefs/pet_move_wkly_tbldef2.asp.

[22] This is a sufficient but not necessary condition for the RFS mandate to

imply ethanol volumes exceeding the blend wall: because advanced ethanol (mainly sugarcane ethanol) is used to satisfy the total advanced RVO, the blend wall could be hit even if the mandated conventional pool is less than 10% of gasoline.

23 The substantial volume of D6 RINs generated by conventional nonethanol fuels, specifically biodiesel and renewable diesel, is a new development. In 2012, conventional biodiesel and renewable diesel generated only 1 million D6 RINs. In 2013, this figure jumped to 250 million D6 RINs, and through the first 10 months of 2014 this figure is 300 million D6 RINs at an annual rate.

24 There are now a number of good treatments of RIN pricing. Irwin provides a lucid description of the basic elements of RIN pricing in a series of posts in farmdocdaily.com and uses a quantitative model of RIN price fundamentals to estimate D4 and D6 RIN prices and to analyze current policy issues and market developments in real time; see in particular Irwin (2013b, 2013c, 2013d). Babcock (2011, 2012) and Babcock and Fabiosa (2012) develop a quantitative model of RIN pricing based on annual subsidy costs, stressing the importance of the blend wall in increasing those costs, and Babcock (2013) uses this model for analyzing the economic welfare costs of the RFS under various E85 penetration scenarios. Meiselman (2014) models the effect of the RFS nesting structure (with three fuels) on RIN prices and economic welfare. Lade, Linn, and Smith (2014) develop a two-period stochastic model with both subsidy values and time values arising from the bankability of RINs and the effect on RIN prices of uncertainty about future policy, and also consider the static implications of a nesting structure with two fuels. They provide additional references to the academic literature, much of which abstracts from the regulatory structure and blend wall details that are the focus of this discussion.

25 Equating the actual RIN price to the subsidy value assumes that the subsidy is in fact passed along to the consumers, which would be the case in competitive markets but not necessarily in noncompetitive markets.

26 Figure 6a shows the market equilibrium value Q_0 to be positive. However, because biodiesel is expensive, it is possible that $Q0 = 0$, that is, no biodiesel would be produced without the RIN subsidy. For example, Irwin (2013a) estimates that no biodiesel would be supplied at a diesel price of less than \$4.00 for prices prevailing in the first half of 2013.

27 Biofuels are not a final product demanded by consumers; rather, the demand curves in Figure 6 are derived from consumer demand for vehicle transportation services and the existing ethanol-related infrastructure, such as the number of flex-fuel vehicles and the penetration of E85 service stations.

28 The full set of inequalities also includes the requirement that the quantity of fuel satisfy its RVO. For a static analysis of nonbankable RIN pricing with RFS fuel nesting, see Meiselman (2014) and Linn, Lade, and Smith (2014).

29 The payoff function of a RIN has additional nonlinear features. Importantly, the RFS nesting structure implies that RIN prices are nonlinear functions of the annual subsidy value for other fuels higher in the nesting structure (the D5 RIN price depends on the conventional subsidy value, for example). An additional nonlinearity arises from the restriction that banked RINs can be at most 20% of the upcoming year's RVO

30 Some have suggested that RIN market speculation, facilitated by a lack of market transparency, also contributed to price volatility, see Morgenson and Gebeloff, "Wall St. Exploits Ethanol Credits, and Prices Spike."

31 Posts on *farmdocdaily* by Irwin and coauthors provide insightful real-time commentary on these developments, see for example Irwin (2014).

32 For example, EPA Administrator Gina McCarthy stated in the context of the 2014 proposed RFS rule, "I have heard loud and clear that you don't think we hit that right" (e.g. Governors' Biofuels Coalition News, Feb. 5 2014 at http://www.governorsbiofuelscoalition.org/?p=8315).

33 See for example NERA (2012), Babcock and Pouliot (2013), and RFA (2013).

34 These calculations assume competition among retailers and throughout the supply chain results in fuel supply costs and savings being passed along to consumers. Previous research on pass-through of changes in oil prices to pump prices is consistent with eventual complete pass-through of oil prices to average pump prices. For example, EIA (2003) Burdette and Zyren (2003) finds 1:1 pass-through from wholesale to retail gasoline prices, although the lag for complete pass-through is long (up to ten weeks, depending on region). Although EIA (2003) finds no asymmetry in the total amount passed through, various researchers have found asymmetric speeds of pass-through, with price hikes passed through more quickly than price declines (see for example Borenstein, Cameron, and Gilbert (1997), Borenstein, S. and A. Shepard (2002), Radchenko and Shapiro (2011)). This asymmetry has been interpreted as some retailers having temporary local market power or temporary information delays among consumers. See Owyang and Vermann (2014) for a recent survey and evidence on regional variation in pass-through asymmetry.

35 The AJW analysis is based on station-level data from E85prices.com, which consists of consumer-reported reported prices so is subject to potential issues associated with nonrandom sampling, however random samples of station-level E85 prices are to the best of our knowledge unavailable.

36 For example, CBO (2012) discusses potential network effects of federal tax credits for electric vehicles.

37 This is the central estimate for a ton of emissions in 2015 using a 3% discount rate, updated to 2015 dollars using the Personal Consumption Expenditure Price Index; see Office of Management and Budget (2013).

38 Petroleum gasoline emits 19.6 lb CO_2 /gal, or 8.9 kg CO2/gal, with a monetized externality value of \$0.375 at a social cost of carbon of \$42/metric ton CO2. For a conventional biofuel with a 20% GHG emissions reduction, the externality reduction value is \$0.075 on an energy-equivalent basis. Because ethanol has 68% the energy content of petroleum gasoline, this externality reduction value corresponds to \$0.052/gal. The full calculation summarized in the text takes into account the interconnection of RIN prices through the RFS nesting structure (the values reported here use the mix of RINs obligated under the 2013 final rule) and ranges of emissions reductions by fuel.

39 See EPA, *Renewable Fuel Standard Program Regulatory Impact Analysis*, February 2012, Table 5.2.6-1, p. 906, at epa.gov/otaq/renewablefuels/420r10006.pdf; following the RIA this estimate reflects energy security benefits only (not monopsony benefits). The first-round macroeconomic effect of an oil price shock on GDP is to increase the dollars sent abroad to pay for oil imports, which reduces the amount of money consumers have for domestic consumption and thereby reduces GDP. This effect scales with the net oil import share in GDP, so producing biofuels domestically reduces this first-round effect of an oil price shock on the economy. These benefits accrue whether or not biofuels prices commove with energy prices as long as the biofuels are domestically produced. Domestic energy production has energy security benefits beyond this effect of reducing the macroeconomic impact of oil price shocks. Although nonconventional oil production has contributed to lower net petroleum imports, the Energy Information Administration projects that the United States will remain a net importer and that net imports will eventually again increase. See CEA (2014) for additional discussion of net oil imports and economic security. The EPA estimates are used here without endorsement of the details of their construction; improving upon EPA's estimates of the monetized energy security benefits goes beyond the scope of the treatment here.

40 The difficult of implementing a quantity regulation, like the RFS, in the face of a steep and uncertain demand curve is an implication of Weitzman's (1974) general theory of quantity vs. price regulation under uncertainty. Some might argue that casting the RFS as a price regulation also faces legal impediments

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because the EISA is a quantity and rate-based regulation which should be implemented without regard to prices and costs (except to the extent that the EISA directs EPA to consider the price of BBD, among other considerations, when setting the BBD RVO, and to consider severe economic harm in the context of the general waiver authority). This view does not bind analysis of the economic effects of the program as is done here; whether it has legal basis in the context of EPA's implementation of fractional standards is a question for lawyers.

41 In the 2013 final rule, EPA summarized the court ruling: "The Court found that in establishing the applicable volume of cellulosic biofuel for 2012, EPA had used a methodology in which 'the risk of overestimation [was] set deliberately to outweigh the risk of underestimation.' The Court held EPA's action to be inconsistent with the statute because EPA had failed to apply a 'neutral methodology' aimed at providing a prediction of 'what will actually happen' as required by the statute" (78 CFR 49798).

42 Cane ethanol and corn ethanol are chemically equivalent but generate D5 and D6 RINs, respectively, because of their different pathways. For the price of round trip transportation to Brazil, cane ethanol can be substituted for corn ethanol, providing a long-run arbitrage that potentially caps the D5-D6 spread. Thus it is unclear in principle whether ambitious support for advanced and a conservative approach to conventional biofuels is feasible (putting aside any legal issues within the RFS).

43 In the 2013 RFS Final Rule, EPA addressed the question of differential application of the cellulosic waiver reduction to the total advanced and total renewable RVOs (78 FR 49810) and argues that the general waiver authority would support differential application of reductions, but not the cellulosic waiver authority. However reducing the total renewable RVO by the full cellulosic waiver, and the total advanced RVO by less than the full cellulosic waiver, would be consistent with the environmental goals of the statute and with the policy goal of supporting low-GHG advanced biofuels including nascent advanced and cellulosic technologies.

44 February 2015 STEO through 2016, AEO 2014 for 2017–2022, where the post-2016 AEO 2014 projection is adjusted in proportion to the relative STEO and AEO projections for 2016.

45 Specifically, low and high gasoline projections were computed using the 2014 EIA Annual Energy Outlook reference case, adjusted up proportionally for the increase in 2014 gasoline consumption between the AEO 2014 and the February 2015 Short-Term Energy Outlook. EIA does not provide bands around the AEO projections, so gasoline forecast uncertainty was estimated by the root mean squared error of the annual revisions to the current-year projections in the January STEO from 2010–2014 (thus omitting the recession), which is 2%. The range of uncertainty about cellulosic fuel growth is necessarily more judgmental and is based on low- and high-growth scenarios. The low-growth scenario has 10% compounded growth of cellulosic, of which 10% is ethanol; the high-growth scenario has 60% compounded growth of cellulosic, of which 60% is ethanol (reaching 1.6 Bgal of cellulosic ethanol in 2022). Figure 9 freezes noncellulosic, nonethanol biofuel consumption at 2014 volumes.

46 A rough calculation indicates that filling the D6 gap solely through expanding E15 would require converting approximately 70% of E10 sales to E15 sales by 2022, based on EIA gasoline consumption projections. Given the challenges facing E15 adoption to date this route seems even more ambitious than significantly increasing E85 sales. In any event, shifting to E15 simply swaps an E10 blend wall for an E15 blend wall and thus does not address the long-term goal of economically efficient production and consumption of advanced ethanol.

47 For example, the supply curve in Irwin (Dec. 13, 2013) indicates an increase in the subsidy value of approximately $2.15 for an increase in domestic biodiesel production from 1.8 to 2.8 Bgal (wet). Because D4 RINs have been approximately $0.50 with production at the rate of 2.0 Bgal per year, adding 1.0 Bgal (wet) of domestic BBD would correspond to an increase in D4 RINs to $2.65. An alternative set of calculations based on soy oil supply elasticities in Hendricks, Smith, and Sumner (2014) and demand elasticities in Adjemian and Smith (2012) suggest lower D4 RIN prices increases for a comparable increase in domestic BBD, ranging from $0.40 to $0.85 (for RIN prices from $0.90 to $1.35). The greatest difficulty with all these estimates is that they entail extrapolating far outside the range of the data, even for 2015.

48 The volumes of BBD in Figure 10a beyond 2015 exceed estimates of current industry capacity. For example, Irwin and Good, Dec. 4, 2013, assume capacity at 3.6 Bgal. EIA [Monthly Biodiesel Production Report, May 2014] estimates capacity at only 2.0 Bgal from currently producing plants. In addition, the projected volumes of BBD far exceed the quantity of biodiesel in B5, although whether that is an issue depends on the extent to which the B5 blend wall is binding (currently unclear) and on the amount of biodiesel that is renewable diesel.

49 The calculations for Figure 10b require an assumption about the total advanced requirement. Here, it is assumed that the cellulosic waiver can be applied differentially to the total renewable and total advanced pool, consistent with the policy aims of the EISA. Specifically, the full cellulosic waiver is applied to the total renewable RVO, but the total advanced RVO is set to be the greater of (i) the previous year's actual production plus the expected increase in cellulosic or (ii) or the total advanced RVO reduced by the full cellulosic waiver. In these calculations the total advanced RVO ends up being determined by (i) through 2016 and by (ii) thereafter.

50 Expanding E85 capacity raises a number of issues, one of which is the need for distribution facilities (stations that carry E85), which in turn requires investment in blender pumps and possibly additional tanks. Babcock and Pouliot (2014) estimate that supplying 2 Bgal annually in E85 would require installing E85 dispensers at 3,000 additional stations, with an associated estimated one-time capital costs of $390 million, or roughly $.20 per gallon of E85, if expensed in a single year. Babcock (2013) makes the point that these capital expenditures appear large, but making them would reduce total compliance costs by bringing down RIN prices by expanding E85 consumption (pushing out the demand curve nonlinearity in Figure 6b).

51 See http://www.epa.gov/otaq/fuels/renewablefuels/documents/carbio-decision-document-2015-01-27.pdf and http://www.biodieselmagazine.com/articles/292077/epa-decision-on-argentine-biodiesel-imports-riles-us-industry.

52 This discussion focuses on nonethanol imports. If cane ethanol imports were to expand to meet the total advanced shortfall, instead of expanding domestic BBD, as assumed in Figure 10b, additional E85 would need to be sold. If selling the additional E85 required high D6 RIN prices, then presumably both cane imports and domestic BBD would expand to fill the total advanced shortfall. Perhaps more significantly, conventional biodiesel and renewable diesel imports could continue to grow.

53 This estimate uses a short-term elasticity of -0.37, estimated using state-level data with tax changes as instrumental variables, see Coglianese, Davis, Kilian, and Stock (2015). Even with an elasticity of only -0.2, the predicted increase in gasoline consumption is 4%, approximately twice the increase in the June 2014–February 2015 STEOs.

54 For example, the Iowa Ethanol Promotion Tax Credit for biofuels retailers and the Minnesota Ethanol Fueling Infrastructure Grant programs. See the Alternative Fuel Data Center at http://www.afdc.energy.gov/laws/.

55 The USDA had supported blender pump installation through its Rural Energy for America Program (REAP); however, the 2014 Farm Bill prohibited

using REAP funds for blender pumps. One argument made for removing blender pumps from REAP is that including them provided a subsidy for a mature ethanol industry. But this misses the point of network externalities associated with expanded E85 capacity as discussed in the previous sections.

[56] EPA, "New Fuel Pathways," http://www.epa.gov/otaq/fuels/renewablefuels/rfs2-lca-pathways.htm.

[57] Even with complete pass-through, parties with net RIN obligations would perceive RIN prices as a cost, in the sense that the RIN costs would appear on their balance sheets as a cost whereas the pass-through of those costs into RBOB prices would not have a comparable offsetting balance sheet line item.

[58] From an accounting perspective, RINs appear as a cost on the balance sheets of obligated parties with net RIN deficits without explicit revenue from RIN price pass-through. The RIN price risk of obligated parties with net RIN exposure could be addressed within the existing administrative structure by policies such as those discussed elsewhere in this section that would aim to reduce RIN price volatility (including forward guidance, resolving the blend wall problem, or a RIN price collar). Alternatively, the fundamental net RIN obligations of some current obligated parties might be addressed through changes in wholesale markets in which RINs are passed back to the seller of the petroleum component of the fuel. Another approach to this problem is to consider making blenders the obligated parties, because blenders come much closer to having a neutral RIN exposure. This switch has potential downsides, however, including making the RIN market even thinner because fewer market transactions would be needed, transferring RIN price exposure to specialized blenders, such as truck stop operators with net RIN exposure, and increasing administrative complexity (there are many more blenders than refiners and importers).

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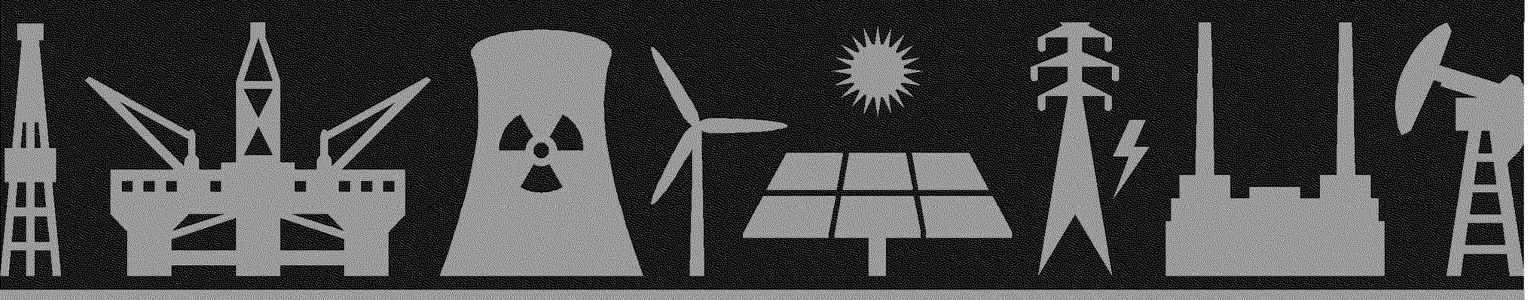

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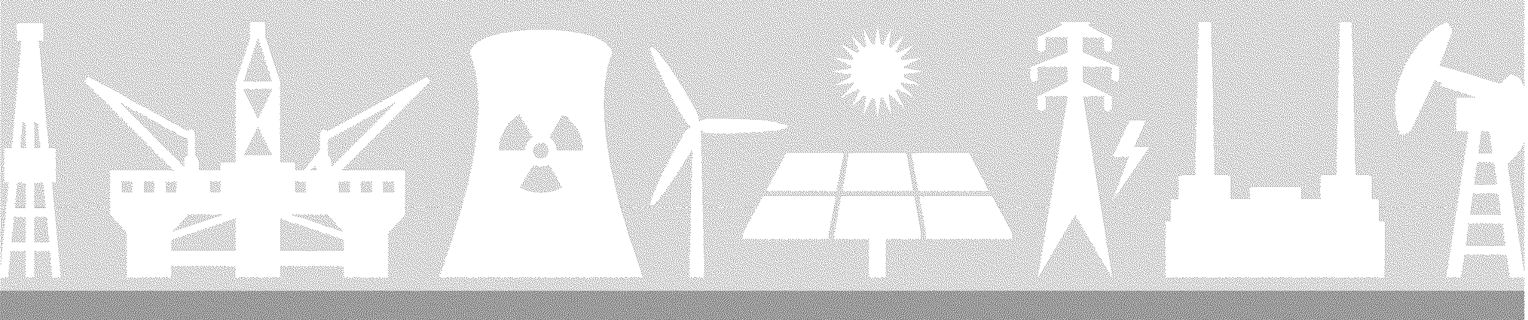

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